MECHANICAL ENGINEERING

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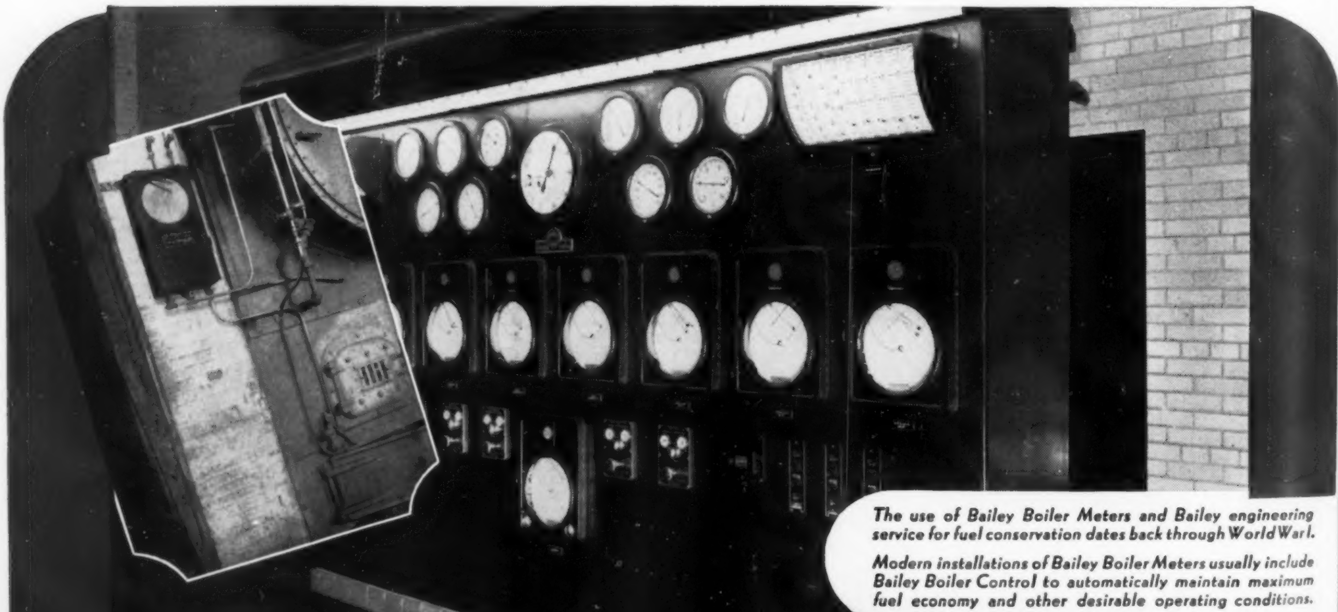

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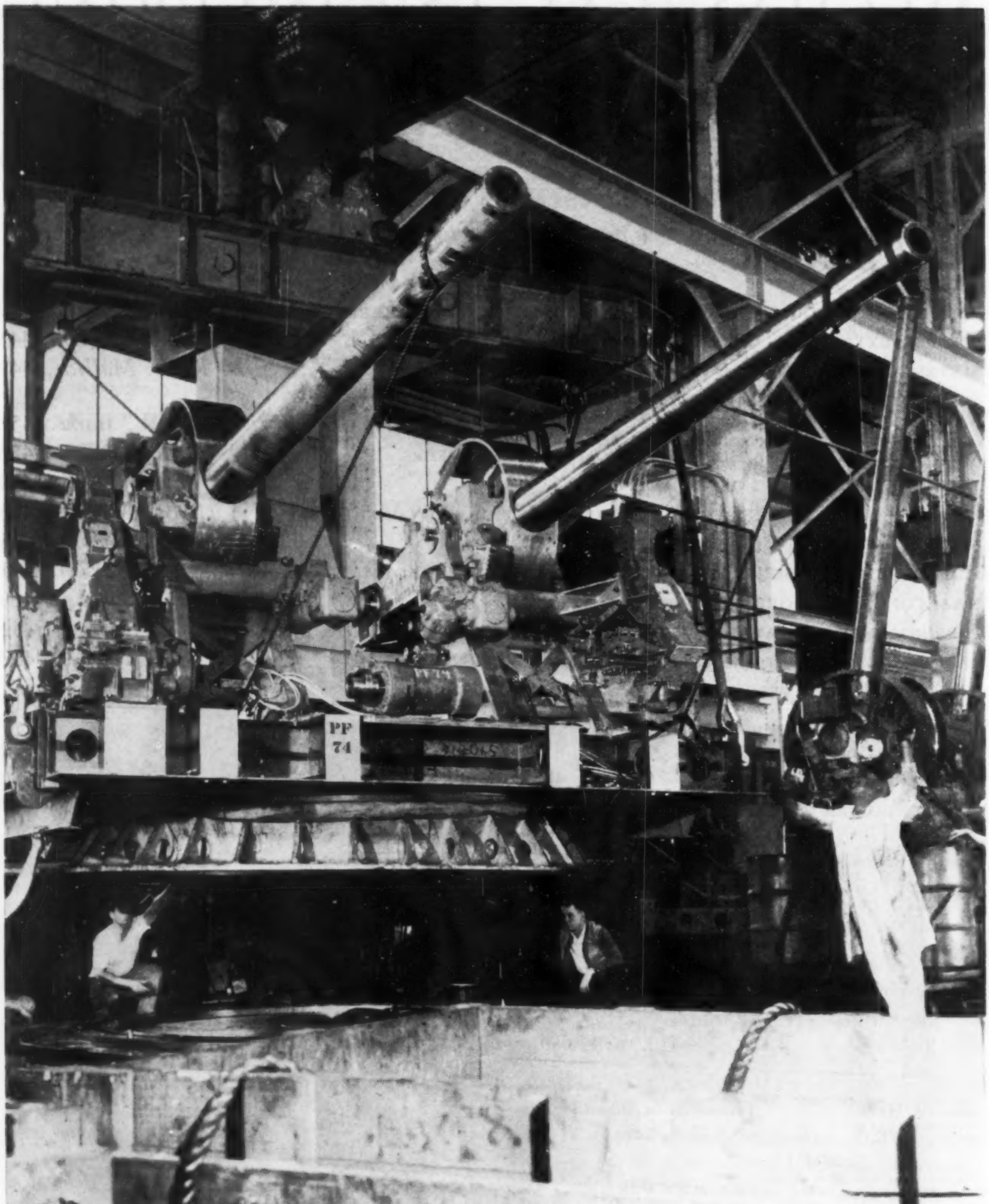

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VOLUME 66
No. 7

MECHANICAL ENGINEERING

JULY
1944

GEORGE A. STETSON, *Editor*

President's Page

The Strength of Numbers

A "professional man" merits that title because of two qualifications: (1) a specialized interest in a field requiring more than ordinary intellectual capacity and application, and (2) a devotion to the service of others, of the common welfare rather than merely his personal advancement.

This definition does not exclude the man who was never graduated from a college. Formal instruction and textbooks are not the only sources of knowledge, and intellectual power cannot be measured by academic degrees. Practical experience may provide fundamental knowledge, even if not so conveniently; and industry furnishes a broad field for developing intellectual capacity. Nor does the definition exclude the man who has made a financial success in business. That may be a result of efficient service to his fellows rather than of selfish concentration on personal gain.

Membership in The American Society of Mechanical Engineers represents scientific or engineering training, experience, and attainment. We have been organized since engineering as a profession began to emerge as the creator and developer of modern industrial techniques for the advancement of the common welfare. The history of the Society runs parallel with that of the modernization of industry.

The first real exhibition of basic mechanical-engineering equipment in America was at the Centennial Exposition at Philadelphia in 1876. When such machines as the huge Corliss steam engine became available, standards had to be developed in anticipation of broader applications of engineering

techniques. There was need of a co-ordinated body of engineering knowledge and a co-operative effort to assemble and extend it. To meet that need our Society was founded in 1880.

At the organization meeting Alexander Lyman Holley, who had been instrumental in bringing to this country the Bessemer process of steelmaking, stated these advantages of such a society: (1) The "collection and diffusion of definite and much-needed information by means of papers and discussions." (2) The "genuine personal acquaintenance thus promoted . . . among engineers and the businessmen associated with them." (3) The "habit of writing and discussing technical papers . . . which engenders habits of thought at once rapid and accurate."

From its beginning the Society was the natural medium for the pooling of professional thought and experience. Today the Society represents the accumulation of what unselfish men could give in time and thought for the advancement of engineering and, through engineering, for the betterment of mankind. We have inherited this accumulation. It can grow by arithmetical or geometric progression. The rate of advance depends on us—on our numbers and our activities.

As president of the Society, speaking for the many members already working loyally and eager to multiply their efforts by putting others to work also, I am asking every member to help us interest other engineers in joining us—for their own benefit and for the further advancement of the common welfare. We have a Membership Development Committee. Names of possible members may be sent to me or directly to this committee.

By increasing our numbers we can multiply many times the benefits that flow from an active association.

(*Signed*) R. M. GATES

President, A.S.M.E.

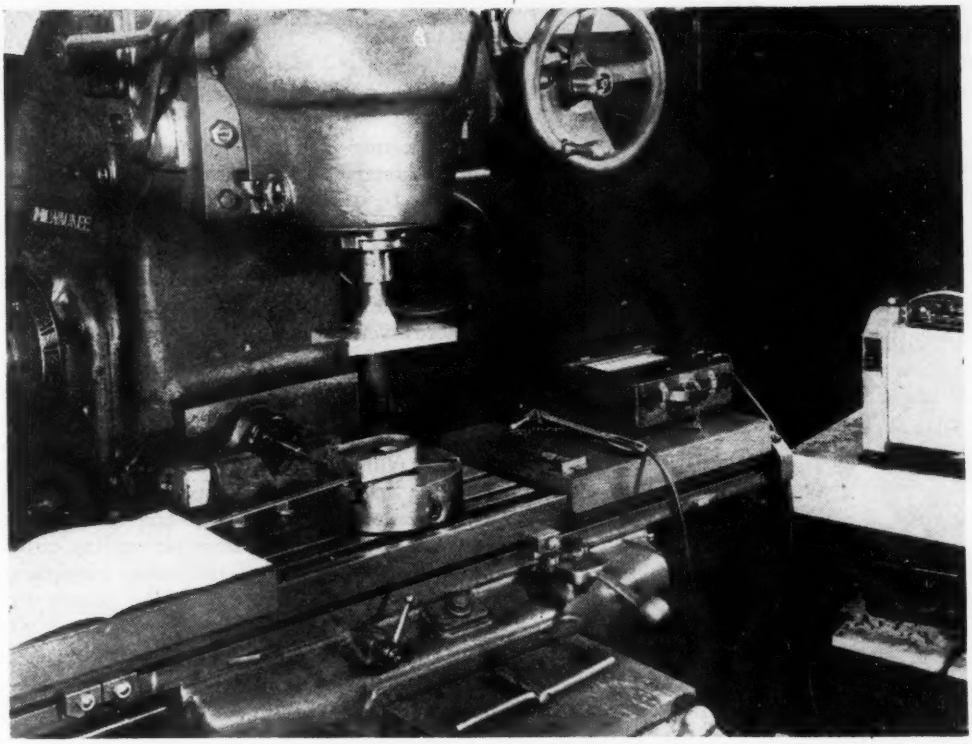

FIG. 1 ARRANGEMENT OF TEST EQUIPMENT

Determining TOOL FORCES *in High-Speed Milling by* THERMOANALYSIS

By A. O. SCHMIDT

RESEARCH ENGINEER, KEARNEY & TRECKER CORPORATION, MILWAUKEE, WIS. MEMBER A.S.M.E.

FOR the experiments, the results of which are presented in a paper by J. B. Armitage and the author,[1] it was necessary to develop reliable equipment and methods to permit accurate determination of tool forces in high-speed milling operations. With the apparatus illustrated, it was possible to investigate the relation between cutting speeds, feeds, tool angles, and workpiece material. Test procedures and sample computations of derived data are included in the discussion.

Several research workers have recognized that the first law of thermodynamics—"When work is transformed into heat, or heat into work, the quantity of work is mechanically equivalent to the quantity of heat"—is applicable in metal-cutting operations. Guided by this fundamental principle, the author, with the co-operation of Professors Gilbert and Boston[2] of the University of Michigan, had previously developed and tested an apparatus for measuring tool forces in a drilling operation. When an investigation of high-speed milling was initiated by the author's company, the calorimetric method was decided upon after a survey of available test equipment had been made. This decision was confirmed by a large number of preliminary tests.

The apparatus is simple, inexpensive, and reliable. Power at the cutting edge of the tool can be evaluated with accuracy at both low and high speeds.

With this method the power required by the tool is determined from the heat in the chips. Distilled water is employed as the medium for measuring the quantity of heat generated by a combination of friction and deformation during the cutting operation. Because of the effect which water may have on milling, the test bars are cut dry and only heat of the chips is measured.

By noting the temperature change of the water into which the chips fall, it is possible to study the effect of workpiece materials, feeds, speeds, and tool angles on power requirements of the tool.

To obtain correct chip temperature and power values, the water equivalent of the calorimeter and chips must be determined. Cutting time for each test should be as short as possible. Rate of cooling must be observed and used in the determination of the theoretical calorimeter temperature which would have been observed if no heat loss had occurred.

Before the test is started, water and equipment should be at

[1] "An Investigation of Radial Rake Anglesin Face Milling," by J. B. Armitage and A. O. Schmidt, presented as a companion paper at the Semi-Annual Meeting of the A.S.M.E., Pittsburgh, Pa., June 19–22, 1944. To be published in the Transactions of the A.S.M.E.

[2] "A Thermal and Mechanical Investigation of the Cutting Properties of Several Metals," Dissertation, University of Michigan, 1943; also contains bibliography pertaining to the subject.

Contributed by the Production Engineering Division and presented at the Semi-Annual Meeting, Pittsburgh, Pa., June 19–22, 1944, of The American Society of Mechanical Engineers.

room temperature to minimize the influence of conditions outside the calorimeter. Drafts and sudden heating or cooling of the air in the test room should be avoided.

Arrangement and shape of the calorimetric equipment is shown in Figs. 1 and 2. Two-bladed 2-in-diam cutters of similar design were used in all the tests which were run on a Milwaukee 2-K vertical milling machine. Cutters with 30-deg 15-deg, 6-deg positive, 0-deg and 6-deg, 12-deg, 20-deg, and 30-deg negative radial rake angles were tested. Steel test bars of 1 in. diam were held in a three-jaw chuck which was secured to the table so that its center line was coincident with the center line of the cutter.

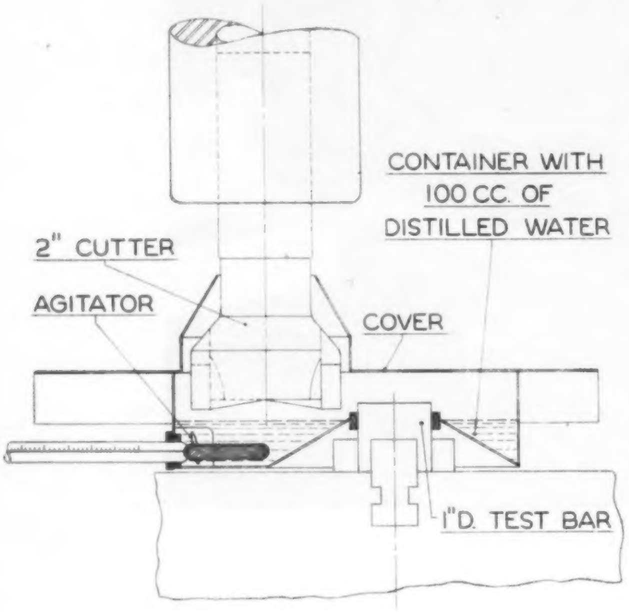

FIG. 2 CALORIMETRIC APPARATUS AND TOOL IN WORKING POSITION

The calorimeter and the cover which fits around the cutter and permits free table movement are made of tin-coated sheet steel 0.012 in. thick. The calorimeter is mounted with a short piece of rubber tubing which fits around the test bar and holds the apparatus suspended in the air. A thermometer calibrated from —20 F to 120 F is fastened in the side with a rubber grommet. A pipette is used to measure 100 cc of distilled water into the calorimeter. An agitator driven by a $^1/_{20}$-hp electric motor through a flexible shaft at 2000 rpm is provided to insure a uniform temperature of the water (see Fig. 2).

A depth micrometer is used to locate the test bar in the chuck. After the machine has been set for the 0.125 in. depth of cut used in these tests, the table stops are adjusted to disengage the table feed as soon as the cut has been finished.

Water temperature is recorded before the test and 4 sec after the cut has been finished, to obtain the maximum temperature increase as brought about by the transfer of heat from the chips to the calorimeter. The agitator is kept running during the test. Surface temperatures of the test bar are measured before and immediately after the cut with an Alnor low-range thermocouple. For additional control, a recording wattmeter is used to register the power requirement of the milling-machine-drive motor.

Power measurements with this equipment do not represent the full value but only that portion which was converted into heat of the chips. However, additional experiments brought out that the percentage of power going into the chips remained constant for all the different rake angles.

The most valuable characteristic of the method presented in this paper was the consistency of test results which gave data within very close limits for the average of a number of individual tests.

DETERMINATION OF CORRECT MAXIMUM CALORIMETER TEMPERATURE

In testing with the calorimetric apparatus, the maximum observed temperature is less than the theoretical maximum which would be attained if there were no heat losses. An interval of time elapses before the observed temperature reaches a maximum value and during this period some heat loss has occurred. If the time interval is comparatively long, or the difference between the initial and final temperature is great, the error introduced assumes importance. Therefore cooling-curve data were taken to determine the correction to be applied to the readings obtained with the calorimeter used in these tests. With the rate of cooling derived from the cooling curve, it is possible to determine the amount of cooling which has taken place before the maximum temperature on the thermometer can be read. In the majority of these experiments, the time of test was a few seconds and the calorimeter correction about 0.1 deg F, which is within the allowable reading error and is generally less than 1 per cent of the actual temperature rise. In most cases, these corrections could be disregarded entirely except in the tests of greater duration or those in which the observed maximum temperature was rather high.

DERIVATION OF FORMULAS AND SAMPLE COMPUTATIONS

Each test cut is 0.125 in. deep on a 1-in-diam steel bar. Therefore the volume of metal removed on each test cut is 0.0982 cu in. Weight of the chips is 0.0278 lb. Total water equivalent of the calorimeter is computed as follows:

0.1970 lb.	Weight of calorimeter
0.0278 lb.	Weight of chips
0.2248 lb.	Total weight of steel

Taking the specific heat of steel as 0.110, the water equivalent of the metal is

$$(0.2248)(0.110) = 0.02474 \text{ lb}$$

Adding the weight of 100 cc of water or 0.2205 lb to the water equivalent of the metal will give the total water equivalent for the calorimeter, chips, and water

$$0.02474 + 0.2205 = 0.2452 \text{ lb}$$

In the following computations, the value of 0.2452 lb will be used as the total water equivalent.

Net horsepower expended on the chips is the mechanical equivalent of the heat increase in the calorimeter divided by the actual cutting time. Therefore

$$\text{Net hp} = \frac{(\Delta T)(\text{water equivalent})}{(\text{Cutting time, minutes})(42.44 \text{ Btu/min})}$$

where

ΔT = calorimeter temperature rise, deg F
1 hp = 42.44 Btu/min

In these particular tests the cut is 1 in. long; the cutting time therefore may be expressed as the reciprocal of the feed rate in inches per minute or $1/F$. Then

$$\text{Net hp} = \frac{(\Delta T)(0.2452)}{(1/F)(42.44)}$$

If the equation is solved with ΔT as the independent variable for each feed used

$$\text{Net hp} = K_F \Delta T \quad [1]$$

where $K_F = \frac{0.2452}{(1/F)(42.44)}$, a constant depending upon the rate of feed in inches per minute. Values for the feeds and other data pertaining to these tests are given in Table 1.

TABLE 1 CUTTING DATA FOR TESTS

Feed, ipm	Cutting time, $\frac{1}{F}$ in min	Metal removed, cu in. per min	K_F
$2^1/_2$	0.4000	0.2452	0.01445
$4^1/_4$	0.2352	0.4170	0.02458
$6^1/_8$	0.1633	0.6010	0.03540
$8^3/_4$	0.1142	0.8590	0.05060
$10^1/_2$	0.0953	1.030	0.06070
$12^1/_2$	0.0800	1.228	0.07225
15	0.0666	1.472	0.08667
$17^1/_2$	0.0570	1.719	0.10110
21	0.0475	2.062	0.1213
25	0.0400	2.455	0.1445
30	0.0333	2.944	0.1734

The horsepower required to mill 1 cu in. of metal per min is computed as follows:

$$\text{Hp per cu in. per min} = \frac{\text{Net hp}}{\dfrac{\text{Volume metal removed (cu in.)}}{\text{Cutting time (min)}}}$$

Substituting expressions and values previously determined

$$\text{Hp/cu in./min} = \frac{\dfrac{(\Delta T)(0.2452)}{(1/F)(42.44)}}{\dfrac{0.0982}{(1/F)}}$$

$$= \frac{(\Delta T)(0.2452)}{(42.44)(0.0982)}$$

$$\text{Hp/cu in./min} = 0.0589\,\Delta T \qquad [2]$$

Maximum average chip temperature rise, ΔT_c, can be computed by two methods. In either approach, the procedure of thermal balance commonly used in calorimetric tests is carried out. The first method of determining the relation between chip and calorimeter temperatures of these tests, assuming 0.110 as the constant specific heat of steel, is as follows:

$$(\Delta T_c)(\text{chip wt})(\text{sp ht}) = (\Delta T)\ (\text{Water equivalent of calorimeter, water, and chips})$$

$$(\Delta T_c)(0.0278)(0.110) = (\Delta T)(0.2452)$$

$$\Delta T_c = \frac{(\Delta T)(0.2452)}{(0.0278)(0.110)}$$

$$\Delta T_c = 80.183\,\Delta T \qquad [3]$$

Values derived with this formula exceed actual maximum average chip temperature rise because the specific heat of steel was assumed to be constant in the foregoing computations. Although this is not the case, the formula does give approximate results.

To determine the maximum average chip temperature rise with greater accuracy the initial equation in the derivation of Equation [3] can be used

$$\Delta T_c = \frac{(0.2452)(\Delta T)}{(0.0278)(\text{sp ht})}$$

Actually the specific heat of steel increases with a rise in temperature, and the formula must be expressed as

$$\Delta T_c = \frac{(8.82)(\Delta T)}{\text{sp ht}} \qquad [4]$$

in which specific heat varies with temperature.

There are no data available for the change in the specific heat with increasing temperatures for S.A.E. 1055. However, chip temperatures were assumed, and the corresponding specific-heat values for gamma iron were obtained from the A.S.M. Handbook.[3] A sufficient number of calorimeter temperature-rise values were computed with Equation [4], using the gamma-iron data to plot a curve which represented the maximum average chip-temperature rise. Thus the true maximum average chip-temperature rise was not determined by the formula, but a corrected temperature value was taken from a curve or a table based on that curve.

Sample Computations:

Data: Depth of cut 0.125 in.
S.A.E. 1055 test bar 1 in. diam
Speed: 1000 rpm
524 fpm
Feed: 21 ipm
0.0105 in. per tooth
Cutting time: $\frac{1}{21}$ min
2.86 sec
Volume metal removed: 0.0982 cu in.
Weight chips: 0.0278 lb
Total water equivalent: 0.2452 lb
Calorimeter temp rise: ΔT, 10 deg F

1 Find net horsepower:

$$(10 \text{ deg F})(0.2452) = 2.452 \text{ Btu}$$

$$\frac{2.452 \text{ Btu}}{^1/_{21} \text{ min}} = 51.492 \text{ Btu per min}$$

$$1 \text{ hp} \doteq 42.44 \text{ Btu per min}$$

$$\text{Net hp} = \frac{51.492 \text{ Btu per min}}{42.44 \text{ Btu per min}}$$

$$\text{Net hp} = 1.213$$

1(*a*) By Equation [1]

$$\text{Net hp} = K_F \Delta T$$

from Table 1, K_F for 21 ipm is 0.1213

$$\text{Net hp} = (0.1213)(10)$$

$$\text{Net hp} = 1.213$$

2 Find horsepower per cubic inch per minute:

$$\frac{0.0982 \text{ cu in.}}{^1/_{21} \text{ min}} = 2.062 \text{ cu in. per min}$$

$$\frac{1.213 \text{ hp}}{2.062 \text{ cu in. per min}} = 0.589 \text{ hp per cu in. per min}$$

2(*a*) By Equation [2]:

$$\text{Hp per cu in. per min} = 0.0589\,\Delta T$$

$$= (0.0589)(10)$$

$$\text{Hp per cu in. per min} = 0.589$$

[3] A.S.M. Handbook, 1939 edition, table vi, p. 431.

3 Find maximum average chip-temperature rise:

From the product of the temperature difference of the calorimeter and the weight of water plus the water equivalent of the calorimeter, the quantity of heat given off by the chips is known. At first this quantity of heat existed in the chips alone. Therefore the 2.452 Btu in the foregoing computations must equal the product of the water equivalent of the chips and the increase in chip temperature during the cutting operation. Assuming the specific heat of the steel as 0.110 and constant, with 0.0278 lb of chips

$$2.452 \text{ Btu} = (0.0278 \text{ lb})(0.110)(\Delta T_c)$$

then

$$\Delta T_c = \frac{2.452 \text{ Btu}}{(0.0278 \text{ lb})(0.110)}$$

ΔT_c = 801.83 deg F maximum average chip-temperature rise

3(*a*) By Equation [3]:

$$\Delta T_c = 80.183\ \Delta T$$

$$= (80.183)(10 \text{ deg F})$$

ΔT_c = 801.83 deg F maximum average chip-temperature rise

4 True maximum average chip-temperature rise cannot be computed readily because the actual specific heat is not known. A curve, derived as previously described, is a simple method of determining a corrected chip temperature from the calorimeter-temperature rise. From this curve, the maximum chip-temperature rise was determined as 620 F.

All formulas given herewith have been plotted graphically in Fig. 3, to facilitate interpretation of test results.

ACKNOWLEDGMENT

This investigation was carried out with the assistance of J. R. Roubik, Department of Engineering Development of the author's company. Grateful acknowledgment is also made to A. R. Segal for incidental co-operation during the experiments, and to J. P. Bunce for his help in checking the manuscript.

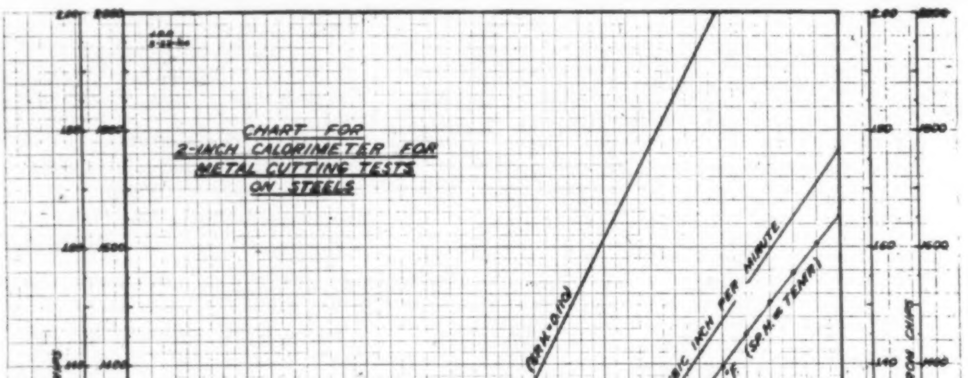

FIG. 3 GRAPHICAL REPRESENTATION OF FORMULAS DISCUSSED IN PAPER

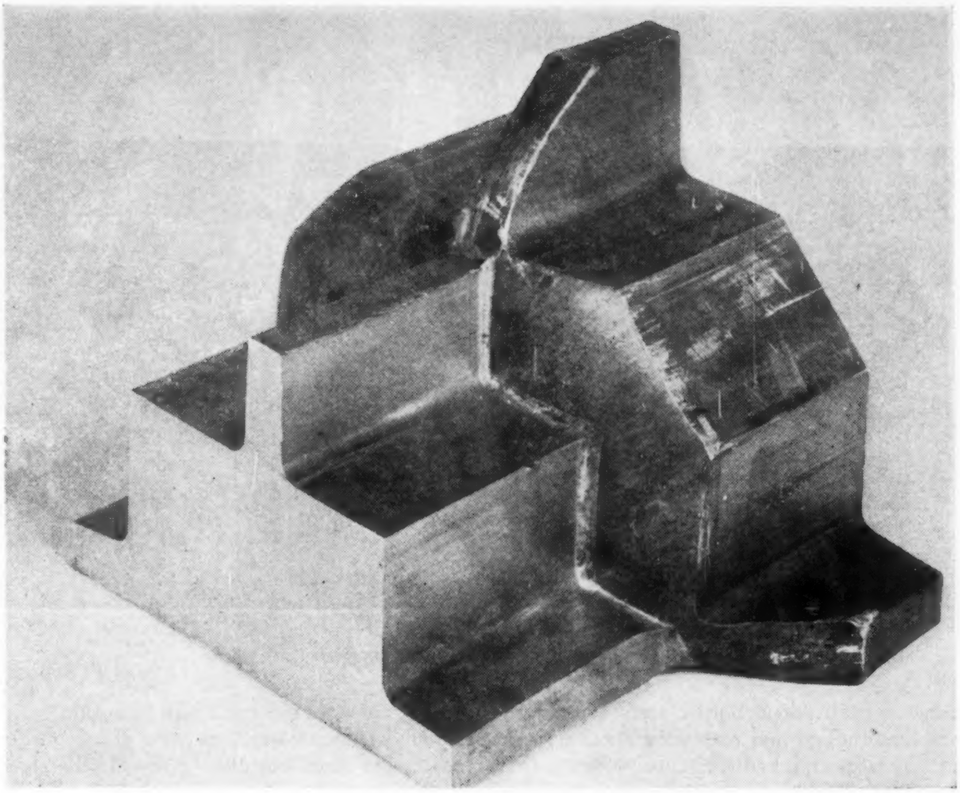

FIG. 1 STEPPED-EXTRUSION SAMPLE, INCLUDING STEP

STEPPED EXTRUSIONS

By KIRBY F. THORNTON

AIRCRAFT SERVICE ENGINEER, ALUMINUM COMPANY OF AMERICA, PITTSBURGH, PA.

THE spar caps used in some aircraft designs involve a great deal of machining to reduce their weight to the minimum consistent with the strength requirements. Stepped extrusions, in some cases, provide economy in material cost and in man-hours required to machine the finished part. When the attach fitting is to be integral with the spar cap, the stepped extrusion is especially suitable. In more than one instance, stepped extrusions have been used for spar caps so large that it would not have been possible to fabricate, on existing equipment, an extrusion having the uniform full cross section long enough for the job.

AIRCRAFT DESIGNS CALLED FOR TAPERED SPAR CAPS

A stepped extrusion is, in effect, two uniform sections made in one piece. Fig. 1 is a "portrait" of a short piece including the step. Up to the present time, stepped extrusions have been used exclusively for spar caps in military airplanes. It is possible that they will have other uses in the future. Soon after aluminum began to be used extensively for aircraft construction, designers began to express a desire to obtain structural members having a cross section varying from end to end. In the early days the extruded shapes used in aircraft construction were small and so did not warrant much expenditure per piece to taper them. In the past few years, however, the design and size of aircraft have changed so that many of the extrusions required are of considerable size. In particular, the shapes used for wing spar caps have in some cases become quite large. The large spars have, in turn, required large attach fittings for assembling the wing panels to the airplane. The use of integral attach fittings and the manufacture of stepped extrusions have developed together.

The present development of stepped extrusions was the result of the need for blanks for tapered spar caps that would require less machining than would be necessary if the part were cut from a bar of constant cross section. Typical sizes and shapes are shown in Fig. 2.

The first actual use was on an experimental airplane. The small section had an area of 1.8 sq in., and the large or butt end had an area of 14.6 sq in. Four different spar caps in each wing were made from this section. Had this airplane gone into production, several different stepped extrusions would have been adopted with the result that each would have been more economical for its intended use. This is a typical application in that the stepped extrusion replaced a uniform extrusion and a forged attach fitting bolted to it. The next application involved eight different stepped extrusions which replaced hammer-forged blanks. The design of the spar caps was not changed. The stepped extrusions were substantially cheaper and required somewhat less machining than the forged blanks. Subsequent applications have, in general, been of the integral-fitting type for which the stepped extrusion is especially suited.

MECHANICAL AND OTHER CHARACTERISTICS

Before offering stepped extrusions to the aircraft industry, the author's company carried out an investigation of their

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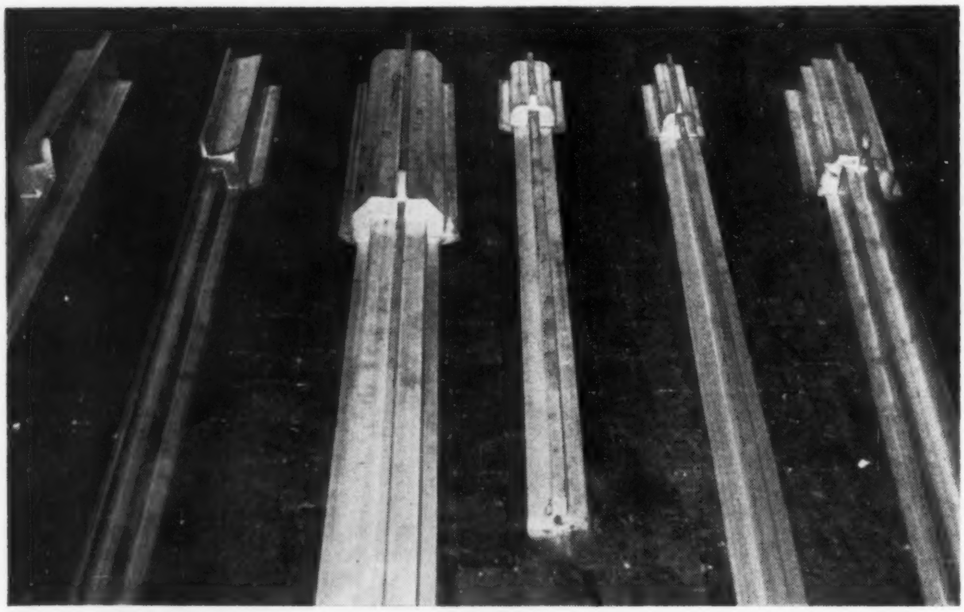

FIG. 2 VARIOUS TYPES AND SIZES OF STEPPED EXTRUSIONS

mechanical properties. Both static tensile tests and fatigue tests were made on longitudinal and transverse specimens cut from the small end, the large end, and the region of the step of an experimental section. The results of these tests indicated that the properties of stepped extrusions were perfectly normal for the alloy and size of section and, further, that the strength of the material at the step is intermediate between the strength in the large section and that for the small section.

Fig. 3 shows two longitudinal sections through an experimental stepped extrusion, etched to reveal the grain structure. Where a fairly heavy part of the section joins the thick part of the butt end, the flow lines are as would be expected. In the lower view we see the result of a thin section (the spar-web attach flange) joining a very thick one. Although the illustration does not clearly reveal what happened during the extrusion process, tests of specimens cut from this exact region of other pieces made with the same tools proved that both static mechanical properties and the fatigue strength were normal.

In production, stepped extrusions are inspected to the same standards that are used for those of uniform section in so far as mechanical properties are concerned. As in the case of large uniform sections, a slice from the end of each piece is etched to determine whether the metal is sound.

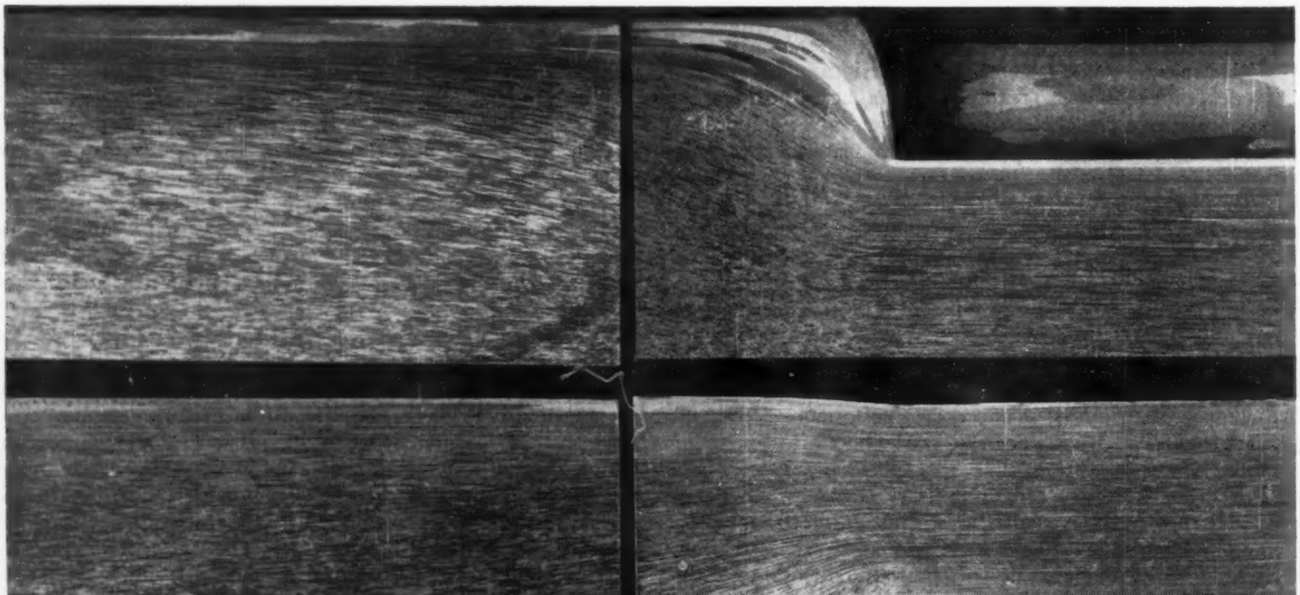

FIG. 3 LONGITUDINAL SECTIONS THROUGH EXPERIMENTAL STEPPED EXTRUSION, ETCHED TO SHOW GRAIN STRUCTURE

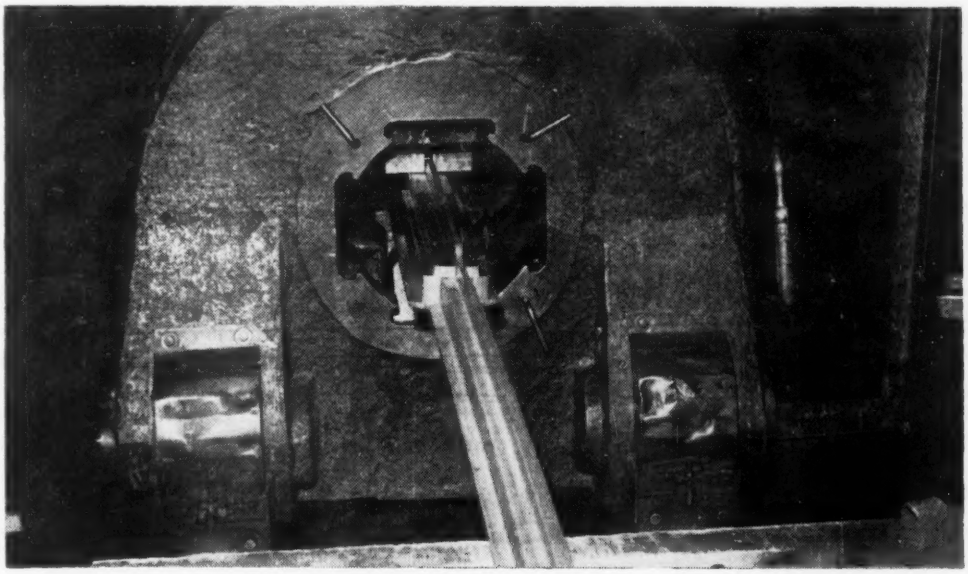

FIG. 4 STRETCHING OPERATION AFTER HEAT-TREATMENT

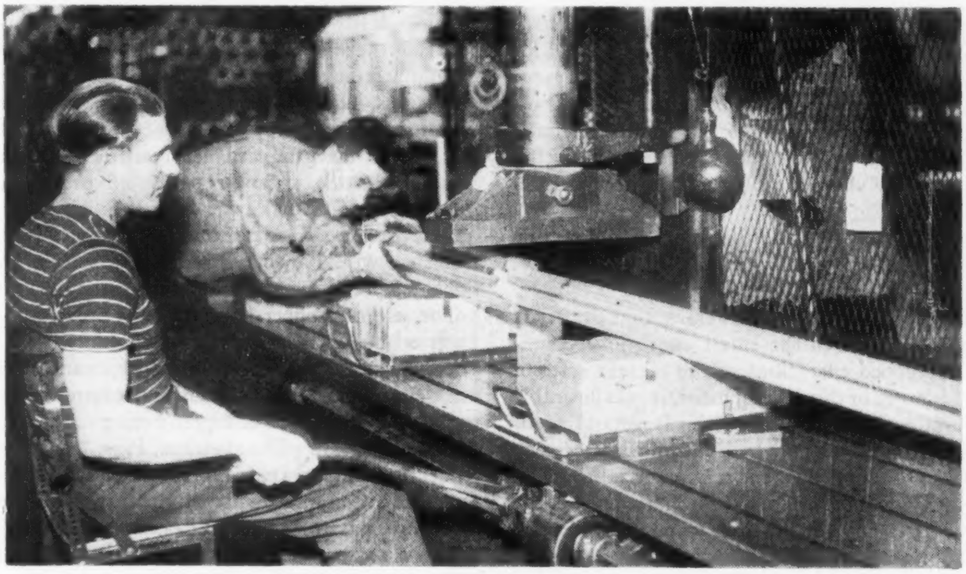

FIG. 5 LARGE SECTION IS STRAIGHTENED IN A GAG PRESS

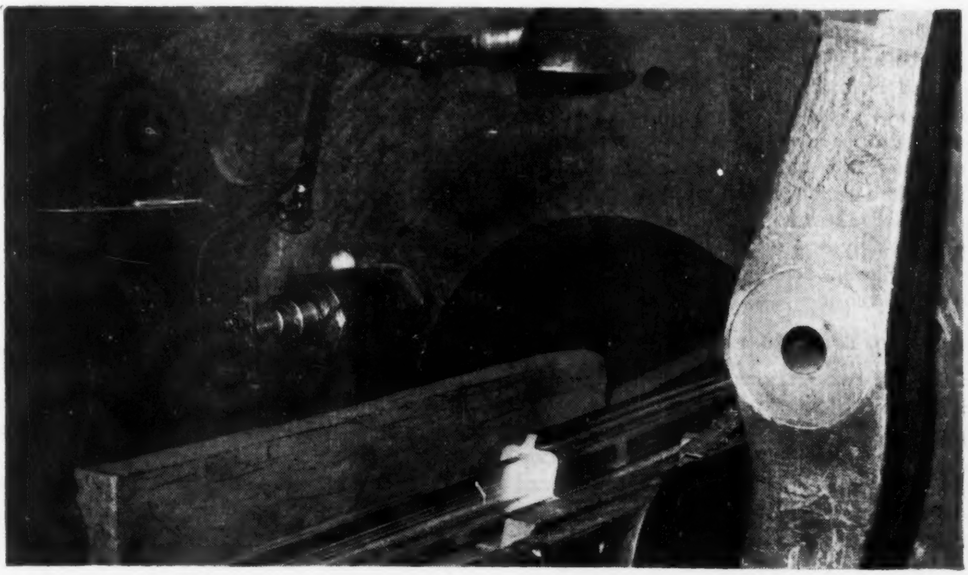

FIG. 6 EXTRUSION PRESS IN OPERATION

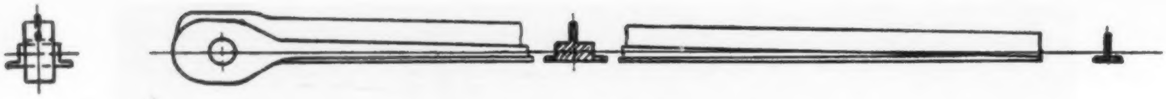

FIG. 7 SPAR CAP WITH INTEGRAL FITTING

FIG. 8 SPAR CAP WITH BOLTED FITTING

FIG. 9 STRAIGHT BLANK FOR SPAR CAP

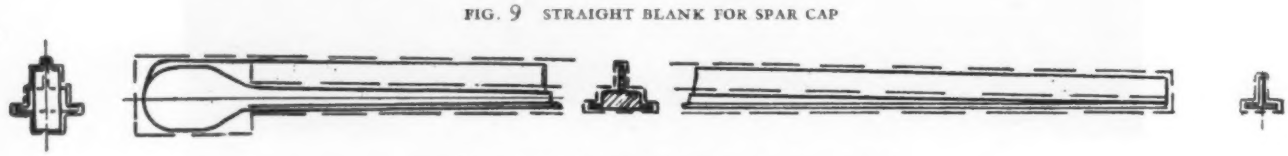

FIG. 10 STEPPED EXTRUSION BLANK FOR SPAR CAP

The stretching operation (Fig. 4) used to straighten extrusions after heat-treatment provides an interesting proof test for stepped extrusions in that the stretcher jaws grip the large section on one end and the small one on the other end. Thus, a load in excess of the yield strength of the small section is transmitted through the step. This provides a convincing demonstration for those who may be skeptical of the structural integrity of stepped extrusions.

Because stepped extrusions are somewhat more complex than uniform ones, they are frequently checked against longitudinal templates representing the parts to be made from them.

It will be observed in all the illustrations that the butt section completely circumscribes the small one. This condition is necessary for stepped extrusions at the present state of the art. In the early stages of the development, it was desirable to maintain one surface common to both the large and small sections. Recently, the limitations which made this necessary have been overcome so that it is now entirely practical to make stepped extrusions having no surface common to both large and small sections. It is not yet possible to produce stepped extrusions large at both ends and small in the middle, or small at both ends and large in the middle. They can only be large on one end and small on the other. It is necessary to limit stepped extrusions to relatively simple sections and to avoid wide thin flanges and certain other characteristics which are commercial in the case of uniform extrusions.

In designing a stepped extrusion to be used as a blank for a given spar cap or other part, it is necessary to take into account the fact that the butt end of the stepped extrusion may not be exactly true and straight in the immediate region of the step. The reason for this is that the stretching operation does not have any effect on the large section, and it must therefore be straightened in a gag press by bending, Fig. 5. Obviously, it is not possible to apply sufficient bending moment to the end of the large section to straighten it.

ACCURACY OF EXTRUSION PROCESS

Accurately matching the two sections with respect to each other depends upon the precision and accuracy of the equipment in which they are made. As shown in Fig. 6, an extrusion press is a rather rugged piece of machinery and its product cannot have the tolerances that would be expected of a machined part. An allowance of $^1/_8$ in. of finish has in the past been adequate to take care of lack of straightness and mismatch on stepped extrusions. Many of the sections in production are straight enough to permit the use of machining allowance of $^1/_{16}$ in. It is worth while to consult with the supplier to make sure that these allowances are adequate and yet not wasteful.

Commercial tolerances have not yet been set up for stepped extrusions, because production has not yet been sufficient to establish what degree of accuracy can be attained. Since the sections so far produced are machined all over, it has been feasible to work on the basis of supplying a blank large enough in all respects to make the desired finished part. This has required the expenditure of more effort on the design of each section than would normally be the case with a uniform extrusion but it has been worth while during the development stages.

The use of stepped extrusions is predicated almost entirely upon economic factors. Each use for which they have been selected could have been fulfilled by means of some other product; either rolled bar, a uniform extrusion, a hammer forging, or a combination of forged fitting with a uniform extrusion or rolled section. The sketches, Figs. 7 to 10, inclusive, are intended to form a graphic representation of the situation. Fig. 7 represents the tapered spar cap having an integral fitting; Fig. 8, an alternative which has been used extensively. This involves a uniform extrusion or rolled shape of medium size to which is bolted a forged attach fitting. Although this construction has the theoretical advantage that the fitting can be replaced without taking the whole wing apart, it is obviously heavier and more expensive because of the large number of special steel bolts required for the scarf joint. Fig. 9 represents the uniform blank, and Fig. 10, the stepped extrusion blank, which would be used for making the tapered spar cap with integral attach fitting. To make the stepped extrusion a better choice than the uniform one, it must be at least 15 to 20 lb lighter.

ECONOMICS OF MULTIPLE STEPS

We have so far discussed stepped extrusions having but one step. Technically, it could be feasible to make them with as many steps as might be desired. Such a procedure would increase the time required to extrude the sections and, in particular, would complicate the straightening problem. The cost of these complications must be weighed against the economic advantage of reducing the weight of the blank as compared to the single-stepped extrusion, just as the single-stepped extrusion has to compete with the uniform one. It is obvious that the first step results in a much greater reduction in weight than any subsequent step could. Up to the present, we have found a number of jobs which amply justified the first step but, so far, none has appeared which would justify a second step.

MATERIAL HANDLING

A Field for Industrial Progress

By R. W. MALLICK

WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, EAST PITTSBURGH, PA. MEMBER A.S.M.E.

MATERIAL handling is the greatest single item of labor cost in most industries. In the United States alone it constitutes about 22 per cent of labor costs and represents approximately a 4-billion-dollar pay roll annually. These are not mere figures; they are facts as evidenced by research reports devoted to the study of material-handling costs in American industry.

Material handling is one very important operation in industry which adds only to the cost and nothing to the sales value of the product. Most customers are not in the least interested as to how many times a piece of material has been handled prior to the time it reaches them for its ultimate use. They are not favorably inclined to pay premium prices simply because the cost of production has been increased by inefficient production methods.

The ultimate consumer is interested only in the quality and usability of the product, and in most instances these things suffer when the product is handled unnecessarily and excessively. For example, Company A is manufacturing a delicate part for a fine instrument. The work is performed on modern precision machine tools and with the finest type of holding fixtures. The part is machined to the tolerance of one ten thousandth of an inch. It is then removed from the machine, inspected, and placed in a container very carefully. Other parts are also placed in the container, which is then moved by hand or by some mechanical conveyance to another department several hundred feet away. The part then may be laid aside in temporary storage to be used for the next operation or possibly to be assembled with other parts. It is then picked up and handled to this next operation. In the handling, parts may come in contact with each other or with the container in which they are carried. Difficulties are experienced in performing the next operation. An inspector is called and a check is made. The part is found to be defective. The tolerances held on the first operation have now been exceeded. This has been a common experience in many industries during this war-production period.

This simple illustration shows that material handling not only directly affects cost of production but can also indirectly affect quality. In handling, parts are often damaged, lost, misplaced, and require additional use of time and facilities.

The time required and the distance traveled in the course of manufacturing a product directly affect its cost. Handling material increases the time in a manufacturing cycle and usually it increases the distance. Both of these factors tend to increase cost. Let us observe for a moment the time factor. Every movement of the material requires time. Time lengthens the manufacturing cycle. The longer the manufacturing cycle, the lower the total output in a given period. The lower the output the higher the cost.

Intensive studies of effective work areas have proved that work areas within the range of a normal sweep of an operator's hands are the most effective for a given performance, see Fig. 1. All work that can be performed by an operator in a fixed position with the work confined to this area will be performed in the most effective manner, all other things being equal. The

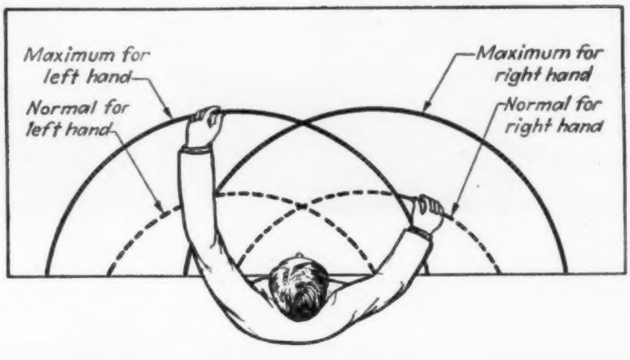

FIG. 1 NORMAL AND MAXIMUM WORKING AREAS FOR THE HANDS IN HORIZONTAL PLANE

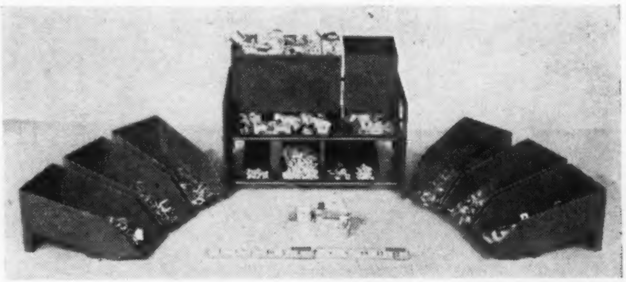

FIG. 2 QUICKLY ARRANGED MOTION-ECONOMY WORK STATION

(The bins are portable units in which material can be stored in lot quantities and by taking the proper number of bin units and arranging them as shown on an ordinary work table, a work station which employs the principle referred to in Fig. 1 can be set up in a few minutes.)

instant the operator finds it necessary to perform work outside this area, he becomes less efficient. This is highly theoretical and depends on many other conditions and factors; however, the theory applies in nearly every case. We know that if material can be brought to an operator at a steady rate, to a predetermined position, and taken away from an operator at a constant rate, from a fixed discharged point, then the operator's effort will be used in the most effective manner. The motions employed by the operator will be used for productive purposes and will not be spent on idle material handling.

This is an ideal condition, and even though it were attainable in all industries, it would not be the answer to every problem. It would reduce the work of the factory operator to that of a robot and would create new problems in the fields of industrial hygiene and industrial relations.

There is, however, much that can be done using this ideal condition as a nucleus around which to work. This can be best exemplified by observing any operation or any condition in the plant at any time. Just casually watch some person doing something in the course of his everyday work and mentally visualize how that simple operation could be improved. We must recognize the fact that persons are not normally conscious of doing things in the most effective manner. They are more inclined to do things in an obvious or expedient way rather than an effective one. Habit has much to do with it.

Contributed by the Materials Handling Division and presented at the Semi-Annual Meeting, Pittsburgh, Pa., June 19–22, 1944, of The American Society of Mechanical Engineers.

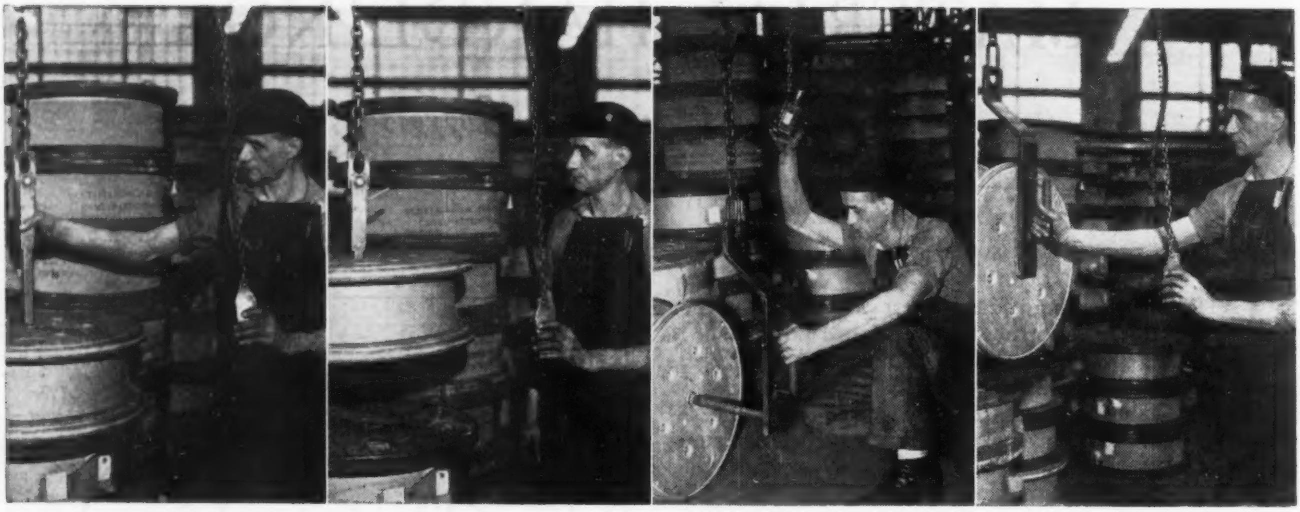

FIG. 3 HANDLING REELS OF WIRE IS USUALLY A DIFFICULT JOB

(The two simple devices shown in these four illustrations make the handling of reels of wire in either a vertical or horizontal position a simple and safe operation.)

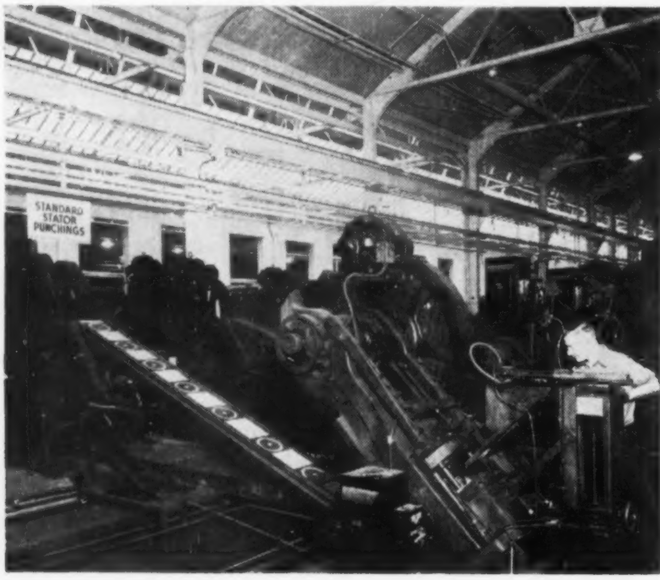

FIG. 4 SEVERAL TYPES OF MECHANICAL DEVICES USED TO GOOD ADVANTAGE FOR MATERIAL HANDLING

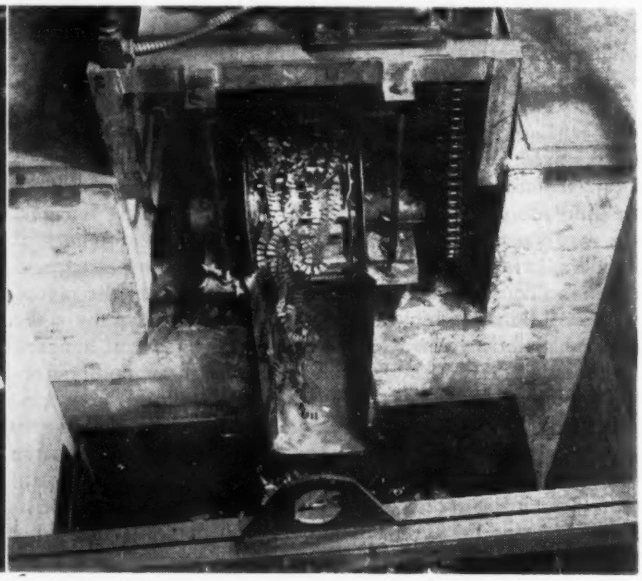

FIG. 5 SCRAP CONVEYER WHICH IS AT STILL LOWER LEVEL AND WHICH CARRIES AWAY THE SCRAP FROM THE PRESS

(The feeding device at the extreme right of Fig. 4 automatically feeds the first press. • The inclined belt conveyer feeds the stamping from the first press into the second press automatically. At the rear of the second press can be seen another press which carries the stamping to the next operation. The two belt conveyers in the trench between the presses carry the finished laminations to the stacking floor.)

We have heard much about the technological development of industry. Certainly we do not today lack technological development from the standpoint of equipment and materials. We have also heard much about the lack of social progress in industry. We have been told that our social and economic progress has been out of phase with technological progress. This subject is too broad to discuss here today. There is a link, however, between this technological progress and social and economic progress which probably does fit the subject of the effective use of labor in industry. Let us look at another example. The machine-tool industry has provided us with machines which are almost incomprehensible in their performance. Their operation is almost fully automatic. I say almost because I think that none of us has ever seen a machine that at sometime or other does not require human attention. Therefore the weakest link of the economic usefulness of this machine becomes the human factor. In many industries today we have such machines whose output is largely dependent on the effectiveness of the operator. If that operator is burdened with material handling, then he is not producing to the best possible advantage, nor is the machine, which represents the capital investment, and, possibly today, a critical part of our war effort. I have seen machines perform operations in fractions of a second while the material-handling preparation required tenfold that amount of time. In many of today's operations these ratios are much greater.

Material handling is frequently a source of industrial accidents. The safety report of one industrial concern in the Pittsburgh area showed that during one month in the year of 1943 a total of 38 lost-time accidents occurred. One of these accidents was fatal. Statistics showed that 21 of the 38 accidents, including the fatal accident, were the result of material handling.

This same company showed a 50 per cent reduction in total lost-time accidents in the preceding year while increasing employment 21 per cent. This plant enjoys an enviable safety

record as borne out by comparison of performance in relation to standards for the state and the industry. These statistics are conclusive evidence that material handling certainly deserves more attention than we are prone to give it.

Industrial accidents are costly in terms of money, and during wartime they seriously affect war production. They are often the source of industrial-relations problems. If improving material handling had no effect on reducing the cost of products, we would still be justified, on the grounds of safety hazards, of increasing our efforts toward improving handling programs.

If we could only learn to regard material handling as a fundamental part of the productive process rather than the mere transportation of materials between processes, we would be inclined to do a much better job of material-handling engineering. We would not dare to disregard the machines and the tools which form and process the materials so that they become useful products, yet we obviously disregard the one common operation which often requires more human effort and absorbs the greatest portion of labor cost while the processing of the product is taking place.

Let me illustrate the economics of this condition. A recent survey, which was made for the purpose of determining the efficiency and cost of drilling holes, showed that only 18 to 20 per cent of the actual time allowed an operator for drilling the holes was spent in the actual removal of metal in the part being drilled. The other 80 or 82 per cent of the time was spent in preparing the material under the drill prior to the time the actual drilling could take place. This was not under poor conditions, as this was a laboratory experiment and the best conditions and the best equipment obtainable at the time were used. Now let us assume that by using better steels, better drill design, improved machine efficiency, and other mechanical factors,

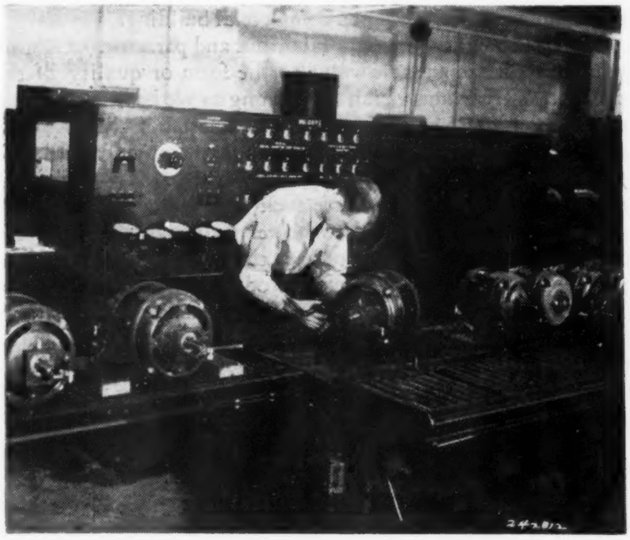

FIG. 6 A TESTING OPERATION ARRANGED IN SEQUENCE WITH THE PRODUCTION LINE SO THAT MOTORS CAN BE INSPECTED AND TESTED WITHOUT UNNECESSARY MANUAL HANDLING OR INTERRUPTIONS

(Note also the overhead crane available where motors have to be removed from the conveyer line.)

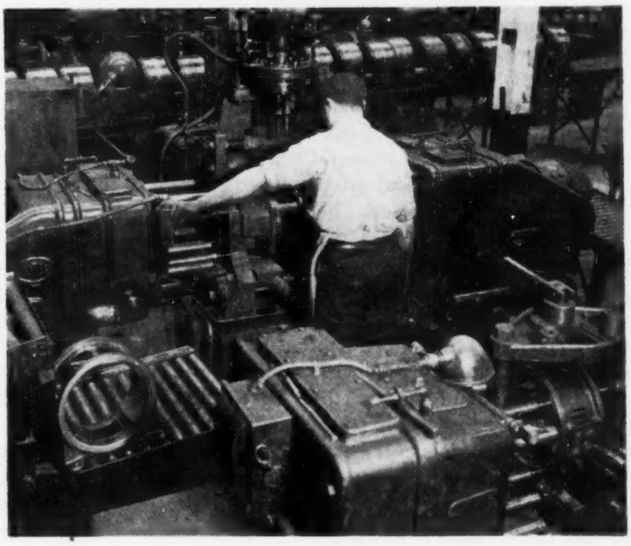

FIG. 7 HANDLING FACILITIES ARRANGED FOR THE USE OF MACHINE OPERATOR

(Here again the principle of work-station layout has been applied so that the operator can perform all of his functions in a small radius and apply most of his attention to the operation of the machine itself and is not concerned with material handling.)

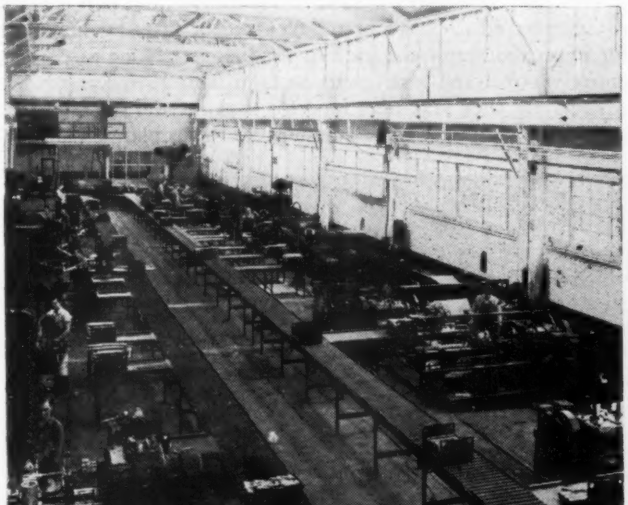

FIG. 8 GOOD EXAMPLE OF MECHANICAL-HANDLING EQUIPMENT WHERE THE WORK SEQUENCE CANNOT BE ENTIRELY STANDARDIZED NOR THE OPERATIONS CARRIED ON IN A SEQUENTIAL ORDER

(By this conveyer arrangement and with lateral stations along the conveyer, material can be prepositioned very easily for the operator and handling greatly reduced.)

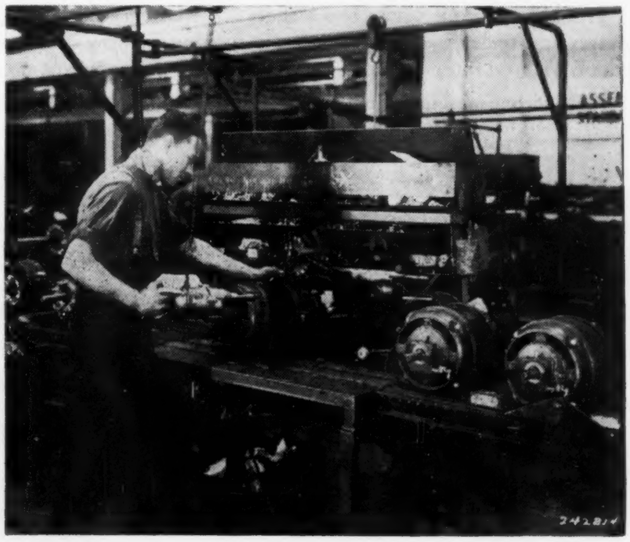

FIG. 9 OPERATION FORMERLY PERFORMED ON A BENCH

(Material had to be moved to the bench and away from it; tools had to be handled by the operator and hardware had to be selected. Now hardware and tools are prepositioned and are readily available and material flows throughout work station without any unnecessary effort on the part of the operator.)

the operation of drilling the hole could be improved 10 per cent. We would still be only gaining 10 per cent of the time consumed in removing the metal, or an over-all gain of about 2 per cent. How much better off we would be if we could gain 10 per cent of the 80 per cent time loss lost in preparation, or, let us say, material handling, which was required actually to drill the hole. Anyone making his own survey will find that although the percentages vary with different operations, the same fundamentals will be reasonably true of conditions in most intermittent manufacturing industries. Yet we continue to spend thousands of dollars and thousands of man-hours on improving machines and tooling setups when one of the greatest sources of loss is in material-handling operations. The reason is that we fail to recognize the true condition that exists.

Although we classify industries as continuous-flow, such as oil refineries, distilleries, certain foodstuff industries, and the like, and intermittent-manufacturing industries, such as most of the equipment and apparatus plants with which we are all familiar, we are prone to accept these classifications too definitely. It is possible and it should be a goal for all plant-layout and material-handling engineers to try to apply the principle of continuous flow to as many operations in intermittent industries as possible. Each time material is stopped in its cycle of process or is set down and picked up, we add to the cost of the product. In a paper[1] presented before The American Society of Mechanical Engineers in 1930, J. I. McCormick, then superintendent of plant planning and layout of the company with which I am associated, stated that it cost $0.0036 to lay an object down on the floor and raise it again to machine or bench level. This cost was arrived at as a result of intensive time and motion study. If that figure was correct in 1930 with the labor rates in effect at that time, then I venture to say that the cost today is $0.005 to $0.006. When we stop to think how many times this handling operation occurs every day, we can begin to appreciate the tremendous tribute we are paying for the handling of materials.

The Mathews Conveyor Company, in its publication entitled, "Natural Laws Applied to Production," illustrates well the progress in the sciences of handling. A comparison can be made between the use of tank cars for hauling oil from oil field to refinery and to points of distribution. This is a good example of intermittent handling. Today, we have pipe lines which do this far more efficiently and far less expensively, yet years ago no one would have been willing to say that pipe lines could replace tank cars for hauling oil over great distances.

Probably in your home town there is a highway with overpasses and underpasses to permit the continuous flow of motor traffic without intersections or grade crossings. Years ago, over these same routes, traffic probably stopped while signals changed and permitted the flow of traffic in one direction while it was stopped in other directions. This is another example where continuous flow can be engineered into designs which are fundamentally intermittent by nature.

As we intensify our engineering efforts in the field of material handling, we shall discover ways and means of improving and applying principles of continuous flow which we never thought possible. For example, for thousands of years the ordinary stairway which you find in every home was felt to be the only suitable means of persons gaining access to upper or lower levels. No improvement was made for centuries. Then someone developed a novel idea that the stair could be made to move while the person stood still and after centuries of believing that there was no way of improving the lowly stairway, we find that inventive genius has given us a moving stairway called the escalator which far surpasses other means of transportation between floors in our offices and commercial buildings.

Material handling being a laborious and parasitic operation, which in a sense adds no value to the form or quality of the product, is truly antisocial, for so long as we have such operations which must be performed by human labor then progress will be impeded and the more abundant life which we all seek will be forestalled. This is especially true in view of the fact that our immigration laws are such that we no longer invite groups of people to our midst who very willingly perform these operations because they do not have the talent, skill, and education required to perform the more productive operations. Also, common labor today seeks a wage which makes it undesirable to man-handle material and thereby increase the cost to the point where the competitive market value of a product is determined by the amount of money needlessly spent in handling it during its production stages.

We shall always have material handling with us, but just as we improved machines and tools and instruments of production so that we no longer have to produce by handicraft methods, so we can apply engineering ingenuity to material-handling operations and continue to progress in this field until it is minimized to the point where only the most essential handling need be done and the more laborious and costly operations will be mechanized or entirely eliminated. If we could only recognize the real effect that material handling has on everyday operation, this process would be greatly accelerated.

The few illustrations that accompany this paper show equipments which have been developed or installations made for improved material-handling conditions. None of these is entirely novel and many will be familiar. However, shown collectively they may offer food for thought and suggest ways and means which may be found useful in your plants.

[1] "Hidden Costs in Materials Handling," by J. I. McCormick, Trans. A.S.M.E., 1930, paper MH-52-12.

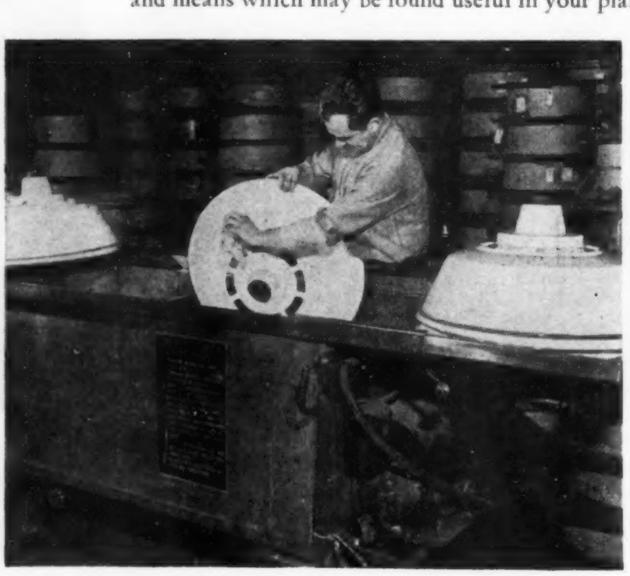

FIG. 10 KEEPING REFLECTORS CLEAN IS IMPORTANT

(The old method was to carry a truck load of reflectors around the plant, replace the dirty reflectors with clean ones, and then take the dirty reflectors to a central point for cleaning. With the device shown reflectors are replaced and washed on the job, thereby saving considerable time and cutting down to a minimum the number of spare reflectors which have to be carried.)

INSTRUMENTATION *and* CONTROL *in the* TEXTILE INDUSTRY

By W. B. HEINZ[1] and W. W. STARKE[2]

TEXTILE equipment at one time was operated almost entirely without instruments. Operators once adjusted the strengths of their solutions by taste. Today, competition demands better methods for producing better goods at lower costs. The war requires the production of new materials quickly and on a large scale.

Instruments and automatic controls help meet these demands by reproducing exactly the best process conditions, by supervising operations, by increasing efficiencies, and by making possible the use of more highly developed operations. Instruments and automatic controls are becoming recognized as essential. However, casual choice of this type of equipment can result in expensive misapplications.

Skillful selection and application of instruments and controls requires careful analysis. Questions such as the following should be clearly answered:

(*a*) *Objectives.* What long-term instrumentation program is being followed? What is to be accomplished, and how important are the results?

(*b*) *Measurements—Control Agent.* What condition is to be measured for regulation, either manually or automatically? This is the controlled variable.

(*c*) *Degree of Instrumentation or Control Required.* Is an indication sufficient, or does the operation require a record? Is manual control dependable enough, or does the job need to be done better than a man can do it?

(*d*) *Type of Control Required.* On-off, proportional, or automatic reset?

(*e*) *Power Medium.* What is the most desirable kind?

(*f*) *Special Conditions.* Are there any unusual factors influencing selection?

OBJECTIVES; INSTRUMENTATION PROGRAM

The history of almost every mill over a period of years comprises successive expansions and contractions of operations, spasmodic additions of new equipment, changes in management and management policies, and, too often, drastic curtailments of maintenance policies. As a result, the existing instrumentation is inclined to consist of a haphazard assortment of units of many different makes in various states of disrepair and miscalibration.

As new production equipment is purchased some consideration is usually given to instruments and automatic controls, although the selection is often left to the judgment of someone who does not grasp the full scope of the problem. A machine manufacturer, for example, not being too familiar with operational conditions in his customer's plant, is apt to overestimate or underestimate the instrument and control requirements.

Instrumentation of existing equipment is often ignored on the assumption that the equipment is already producing at full capacity. Actually, correct instrumentation may improve the performance of a plant sufficiently to reduce the need for new equipment by exposing correctable shortcomings and maladjustments.

In order to gain the maximum profit from instrumentation, it is necessary to establish a comprehensive policy for the entire mill. The first step is to survey existing operations and existing instrumentation, noting particularly their respective conditions and limitations. From this survey, a master instrument and control schedule is developed to fill in the gaps, to provide additions where justified, and to program needed rehabilitations and replacements. Once a sound basic policy has been established, its execution can be budgeted, and new instrumentation can fit into the over-all pattern.

Such a plan should include schedules for periodic servicing and calibration under the supervision of a central group. The individual production operator is prone to be content with an instrument as long as the pointer moves, and there are no obvious production faults. Since a miscalibrated instrument can readily cause a constant operational error, it is important that instruments be maintained in a reliable condition. Where the work is not sufficient to occupy one man fully, selection of an individual for this work should consider his usefulness for related work, such as testing and adjustment of driers, supervision of steam, water, and power distribution, air conditioning, or conservation work on these services. In fact, a key to a successful instrumentation program is a permanent organization unit to carry out this function and to co-ordinate allied work.

Before specifying measurement and control apparatus, the objectives should be correctly understood. For quality maintenance, the critical factors are the tolerances permitted before the product is affected, the amount of harm possible, the suddenness with which fluctuations occur, and the complexity of demands on the operator. The need for instruments or automatic control is frequently obvious, and the problem resolves itself into the degree of control required.

For capacity maintenance, by reducing variations, and by reducing the human element, it is possible to operate equipment at its maximum rate. For example, a drier operator may carry a lower air temperature than necessary to allow for fluctuations when his attention is engaged elsewhere, thereby sacrificing some capacity. In a dyehouse, a closely controlled temperature of preheated water saves heating-up time in the machines.

Conservation objectives include savings in manpower, in material, and in services such as steam and electricity. In most operations, direct personnel reduction is not possible by either instruments or automatic control alone. However, by reducing the complexity of the task, and by eliminating some of the variable conditions, less skillful operators may be employed, and the task of training new operators is reduced. Where there are numerous similar units, as in a dyehouse, a saving in the number of operators may be accomplished by increasing the number of units operated by one man, or by subdivision of labor. Automatic control and work-simplification studies together may effect a saving in labor where either alone may not be able to save an operator.

Conservation of material is possible where spoilage or deterioration of the product is reduced or prevented. For example, boiling operations in dyeing affect the strength of the material. By holding dyeing cycles to the exact time required, the product is more uniform in quality, and the fabric designer

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Contributed by the Textile Division and presented at the Annual Meeting, New York, N. Y., Nov. 29–Dec. 3, 1943, of The American Society of Mechanical Engineers.

TABLE I — OBJECTIVES FOR INSTRUMENTATION IN TYPICAL TEXTILE OPERATIONS

		SUPERVISORY OBJECTIVES			CONSERVATION OBJECTIVES		
Operation	Kind of Measuring Instrument or Control	Quality Maintenance	Capacity	Manpower	Material	Steam, Water, Electricity	Other Objectives
DYEING							
Dye Liquor	Automatic Temperature Control and Indication	Duplicate standard conditions	Reduce waste time in adjustment of temperature	Reduce operating attention	Reduce deterioration	Reduce excess heating	Reduce boiling over hazard. Operational record
Dye Liquor	Pressure Indication	Duplicate standard conditions	Indicate pump shortcomings	—	Reduce deterioration	—	—
Dyeing Temperature cycle	Automatic Time Cycle Control	Duplicate standard conditions	Reduce excess time	Reduce operating attention	Reduce deterioration	Reduce excess operation	—
Dyeing Liquor Flow Cycle	Automatic Flow Reversing Control	Duplicate standard conditions	Reduce excess time	Reduce operating attention	Reduce deterioration	Reduce excess operation	—
Preheated Water Supply	Automatic Temperature Control	Duplicate heating cycle in machine	Reduce heating time in machine	—	—	—	—
Water Supply	Pressure Indication	—	Indicate supply shortcomings	Reduce machine filling time	—	—	—
Water Supply	Meter	—	Indicate excessive demands	—	—	Check operating economy	Costing record
Steam Supply	Pressure Indication	—	Idicate supply shortcomings	Reduce heating time	—	—	—
Steam Supply	Meter	—	Indicate excessive demands	—	—	Check operating economy	Costing record
DRYING							
Air Temperature	Automatic Control or Indication	Avoid over temperatures	Avoid under temperatures	Reduce operating attention	Reduce possibility of material damage	Avoid overheating	—
Humidity of Drying Air	Auto. Control of Make-up Air or Indication of Humidity in Dryer	Maintain optimum conditions	Permit higher feed and temperature and avoid excessive makeup air	Reduce operating attention	Reduce possibility of material damage	Avoid heating up excessive makeup air	—
Rate of Travel of Material	Auto Control or Indication of Conveyor Speed	Avoid overdrying	Adjust to most efficient speed	Reduce operating attention	Reduce possibility of material damage	Savings by efficient operation	—
Moisture Content of Delivered Material	Moisture Indication or Control	Avoid over or under drying	Adjust to most efficient operation	Reduce operating attention	Reduce possibility of material deterioration	Savings by efficient operation	—
Air Circulation	Manometer	—	Maintain full air flow	Indicates clogged screens	—	Savings by efficient operation	—
Steam Supply	Pressure Indication	—	Indicate supply shortcomings	—	—	—	—
RING SPINNING							
Room Conditions	Automatic Temperature Control and Indication	Maintain correct temp. for fiber workability	Reduce breakage anu permit higher rate of operation	More production per worker. Save hand control of humidity	Reduce waste	Reduce excess heating	—
Room Conditions	Automatic Humidity Control and Indication	Reduce effect of static electricity	Reduce breakage and permit higher rate of operation	More production per worker. Save hand control of heating	Reduce waste	Reduce excess heating	—
Machine Speed	Antomatic Control and Indication	Operate at correct speed for yarn and bobbin winding	Operate at maximum speed for yarn and bobbin winding	More production per worker	—	—	—

can cut down on his strength allowances. This is of greatest value in early operations, such as stock dyeing, before material receives the mechanical abuse of later operations.

Conservation of steam, water, electricity, and gas are possible (1) by metering consumptions for comparison with production, (2) by individual control over units to reduce excessive heating or operating time, (3) by operating equipment more efficiently, and (4) by facilitating operation to stagger loads. Individual savings may not justify instrumentation, but a composite plant program often saves needed generating and distributing capacity.

Other considerations may indicate the use of instruments and controls. Among these are the reduction of safety hazards, such as boilovers records for accounting purposes, and data for rate setting. Savings in operations are possible by general plant instruments, such as water-condition analyzers, instruments for testing and adjusting equipment, and instruments for operational analysis, such as the stroboscope.

Table 1 gives the objectives for typical textile operations. In most cases it is difficult to predict quantitative savings for any one installation, and the engineer must use judgment, based upon his knowledge of the operation.

MEASUREMENT; CONTROL AGENT

Several different conditions may vary during a process operation. It is important to identify the condition whose measurement gives the best guidance to an operator or the most effective actuation of an automatic controller. In a can drier, the temperature condition in each unit is indicated either by direct temperature measurement or by measurement of the steam pressure in the can.

Temperatures are measured by thermocouples, resistance thermometers, and by expansion- and pressure-type thermometric systems which are either gas-filled, liquid-filled, or vapor pressure. Pressures are measured by manometers, and by gages utilizing Bourdon tubes, helices, spirals, bellows, diaphragms, and the like. Liquid levels are measured by various arrangements of floats; by direct measurement of pressure at a point beneath the surface; by the pressure required to force gas into a liquid at a point beneath the surface; and many others.

The flow of fluids is measured most commonly by means of orifice meters, actuated by the pressure drop across an orifice or a nozzle in the line. During recent years a new contender in the field has become prominent, i.e., the rotameter, a tapered transparent tube, through which the liquid flows vertically. A weighted float in the tube rises to a position where the annular space between it and the tapered-tube wall is just large enough to pass the required flow. A scale on the tube is calibrated directly in terms of flow.

The orifice meter employs an orifice of fixed area, the measurement being provided by the variable pressure drop as the flow changes. The rotameter, on the other hand, operates at constant pressure drop (determined by the weight of the float) while the orifice area is varied by the rise and fall of the float in the tapered tube.

The principles of measurement for pH and conductivity are sometimes mistakenly thought to be the same. Measurement of pH utilizes an electrolytic potential, depending upon the hydrogen-ion content in the liquor, whereas, conductivity is a measurement of the ability of the liquor to conduct electric current. Conductivity depends upon other factors besides the hydrogen-ion content. Conductivity measurements are frequently used to indicate the purity of water and other liquids. A pH measurement indicates the need for acid or alkali.

Other process variables include weight, tension, speed, position, humidity, turbidity, and moisture content.

DEGREE OF INSTRUMENTATION

A simple indicator such as a pressure gage or thermometer is frequently sufficient. In operations where trends are simple and fluctuations are slow, occasional observation by the operator permits the necessary adjustment. In some cases secondary instrumentation by an indicator is installed for trouble shooting. For example, if heating cycles stretch out, a steam pressure gage on the main shows if the cause is low steam pressure.

Recorders are used on important or more complex operations where a historical record is desirable. A recorder is invaluable in connection with automatic control of a difficult process because of its aid in adjusting the controller. Recorders are useful where measurements fluctuate constantly, and a correct average condition is to be maintained. On important operations they give the departmental supervisor a record of the performance of his operators and equipment, and, in cases of production troubles, they are useful in tracing causes.

Integrating instruments are of value for accounting records, such as steam, electricity, or water consumption. Mechanical counters are a form of integrator useful for checking production and establishing piecework rates.

Modern recorder-controllers (or corresponding indicating controllers) include the most highly developed control mechanisms on the market. They should be used whenever the best control performance is wanted. Cost differences, as compared with combinations of independent controllers and recorders, are usually unimportant.

Variables are frequently controlled by adding control mechanisms to measuring apparatus. Such controls may be self-actuated, by energy furnished from the process itself; or they may be servo-actuated, utilizing power from electricity or air, water, and the like. Servo-actuated controllers are always more sensitive and precise and are substantially the same in reliability as self-actuated devices. The trend is definitely toward more extensive use of servocontrols.

Although an operator with an indicating instrument can perform some functions as well as an automatic controller, no operator can match modern controllers in repeating identical cycles, and in many continuous processes. A good recorder-controller will start corrective action before its own pen has started to move, and before an indicator will have made a readable response to guide an operator. However, good practice provides for manual operation also.

The use of automatic control is indicated in the following cases:

1. Regulating functions require almost constant attention.
2. Fluctuations are too rapid for manual control, or so slow and complicated that an operator cannot foresee what he must do for a future correction.
3. Lapse of operator's attention would cause substantial loss in quality or capacity.
4. Operating labor can be saved or lower-grade operator can be used.
5. When control should be centralized.

TYPE OF CONTROL REQUIRED

The major technical requirements of a controller determining the control action which it should provide are (1) fast correction of a deviation in the controlled variable; and (2) adequate stability. Needless to say, it must also be thoroughly reliable.

Process properties, valve characteristics, and controller adjustments are factors which determine the performance of the system. The process properties which influence control are of only four basic kinds, i.e., capacitance, resistance, dead time, and self-regulation. The numerous lags and capacities can all be reduced to various combinations of capacitances, resistances, and dead time. A self-regulating tendency in a process cannot similarly be broken down into the same components, and self-regulation must be accepted as an independent property.

Fundamentally, every automatic-control problem is one of regulating the transfer of energy or material. Temperature control usually involves the regulation of heat-energy exchange. Control of pH deals with the transfer of materials, as does flow control. Pressure control is accomplished in some cases by heat exchange and in others by the exchange of materials. Speed control involves the transfer of mechanical energy.

The significance of the generalized properties which we term capacitance and resistance can be developed by reference to a standardized figure, suggested by the heat-transfer analogy published by E. D. Haigler of Foxboro in 1938. Fig. 1 shows a simple heat exchanger. A heat-supply liquid enters at the bottom left through a controlled valve, flows up through the supply side and out again. Heat from the supply side passes through a heat-transfer surface into the demand side of the heat exchanger, through which flows a fluid whose temperature is being controlled.

The point where the temperature is measured by the controller is downstream from the demand side of the heat exchanger by an amount which determines the dead time between a change in the demand-side temperature and the sensing of it by the controller bulb.

We have here supply-side capacitance, resistance, demand-side capacitance, and dead time. This process also possesses self-regulation.

Fig. 2 illustrates self-regulation. The first tank is self-regulating. If the controller were not working and the inflow were too great, the head would increase until the outflow through the exit orifice would equal the inflow.

The second process possesses no self-regulation. The outflow, being handled by a positive-displacement pump, is not affected by the head. In the absence of control, any slight deviation in the inflow from equality with the outflow will produce a continuing change in the level.

The significance of the term self-regulation is much the same

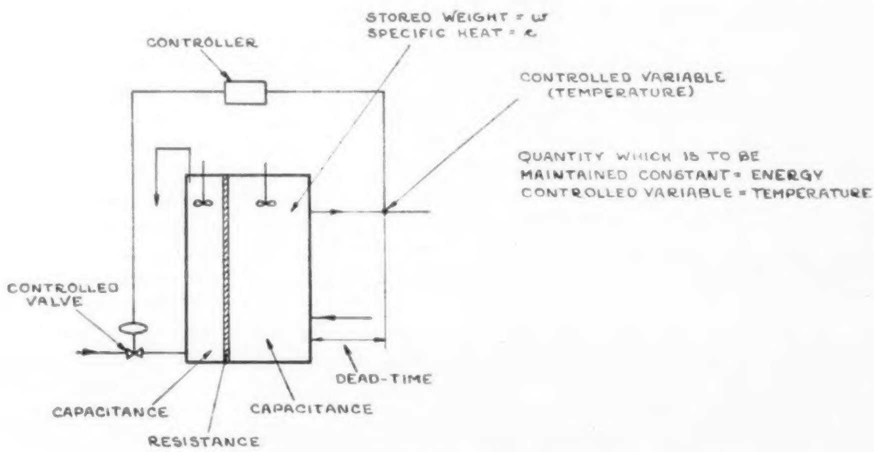


FIG. 1 DIAGRAM OF SIMPLE HEAT EXCHANGER TO BE CONTROLLED
(Quantity which is to be maintained constant = energy; controlled variable = temperature.)

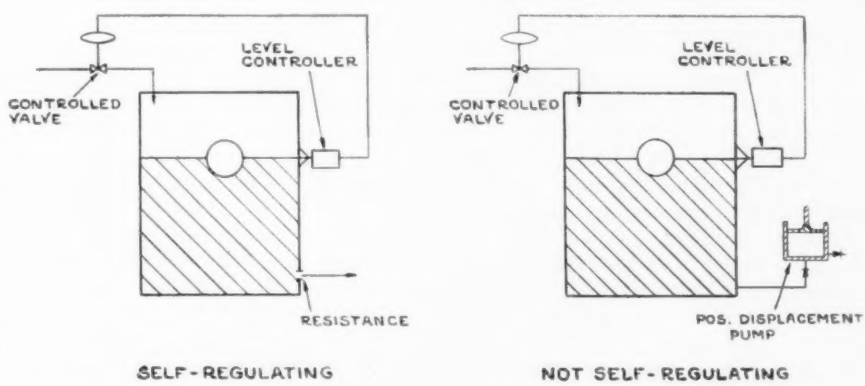


FIG. 2 DIAGRAMS OF SELF-REGULATING SYSTEM AND ONE NOT SELF-REGULATED

in any other kind of process, the heat exchanger for example.

The foregoing are the basic properties of all processes which must be considered in analyzing or judging controllability. There has as yet appeared no toolbox method for easy advance determination of the control behavior of a process, except the simplest types. Control of the process shown in Fig. 1 can be made easier in the following ways:

1 By selecting a small thermometer bulb and locating it directly in the stirred tank instead of downstream as shown, thus eliminating the dead time.

2 By exposing the bulb itself directly to the interior of the tank instead of using a thermometer well.

3 By keeping the supply-side capacitance small.

4 By keeping the resistance small.

5 By making the demand-side capacitance large.

Temperature control in an open water tank provides a typical example, particularly if the water is heated by direct steam injection. Another case is control of water level by means of a float-type controller. A third example is temperature control in a steam-heated drier with good air circulation and good heater and bulb characteristics.

The converse of any of the foregoing considerations will make control correspondingly more difficult, as indicated in Fig. 3.

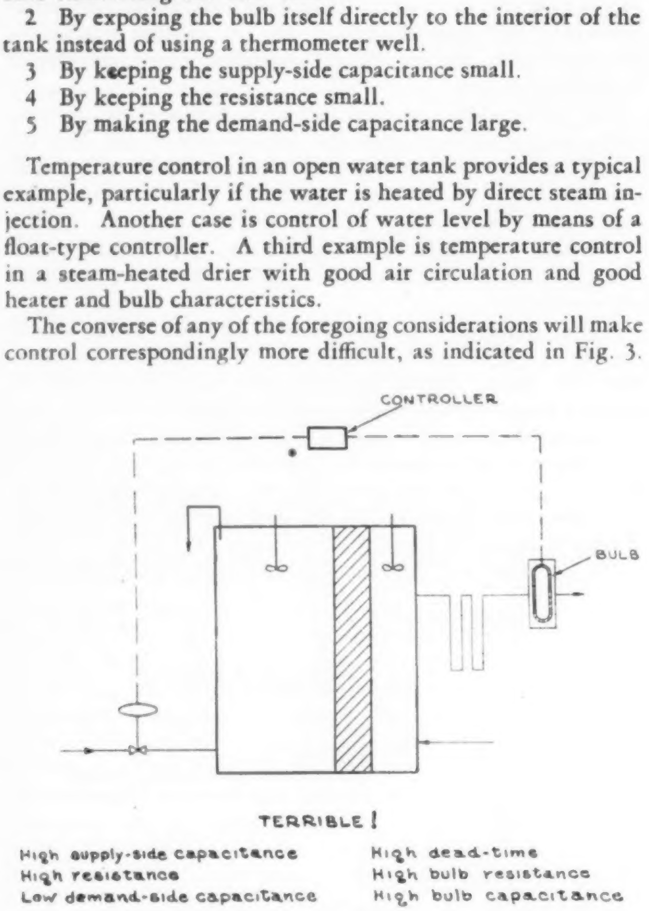


FIG. 3 SELECTION AND LOCATION OF INSTRUMENTS MAKES CONTROL UNSATISFACTORY IN THIS ARRANGEMENT

The supply-side capacitance is large, the transfer resistance extreme, the demand-side capacitance small, large dead time, and a bulb installation which includes all the bad features. Typical process temperature-control examples which include part or all of the bad features are (*a*) a jacketed size kettle, steam-heated, (*b*) the dye trough of a padder or a jig, and the size box of a slasher (poor agitation and heat transfer), and (*c*) a Xanthate dissolver, brine-cooled.

It should be recognized that temperature control in a storage-type water heater (a shell around a steam coil) is often erratic on account of the absence of stirring to maintain uniform conditions. To this type of heater no simple analogy applies. The temperature bulb must be judiciously located with particular consideration of each set of conditions.

The control effects most widely used are two-position, proportional, and proportional-plus-floating (automatic reset). Two-position control may utilize a wide differential, or dead zone, between the water tank level at which a pump is started, for example, and the level at which it is stopped.

When there is no appreciable dead zone we have on-off control. A sensitive on-off controller is the best choice for many applications, notably those including strong self-regulation, small resistance and supply-side capacitance, and large demand-side capacitance.

Proportional and proportional-plus-floating controls are also known as throttling controls because they hold a valve partly open. With proportional control, the valve-stem lift is proportional to the deviation of the controlled variable from the set point. Thus a deviation is necessary to open the valve wider after an increase in load; and this control is subject to load error, or "drift."

Proportional-plus-floating control (automatic reset) keeps the valve slowly moving beyond its proportional position until the controlled variable reaches the set point. This control can handle all loads without any permanent deviation.

The flow characteristic of the controlled valve is another important consideration except in the simplest control. On-off control should use a quick-opening valve of any convenient size. Throttling control requires a valve to change the flow gradually as the stem rises. Its size must be correct for each process.

For the majority of processes, it is not necessary to go through an elaborate analysis of the capacitances, resistances, and dead time, and their influence on controllability. Many applications can be judged by previous practice.

Water-Supply-Tank Temperature. An open water-supply tank almost invariably has low supply-side capacitance, small heat-transfer resistance and large demand-side capacitance. This is particularly true if the water is heated by injected steam. These conditions are favorable to control. Proportional control is usually unnecessary for stability. Furthermore, any appreciable proportional band is actually undesirable, because pickup is slow. This is particularly true when water is withdrawn batchwise.

Self-actuated controllers have proportional bands too wide for the best results. Pilot-operated types are satisfactory. They are actually servo-operated by the steam pressure they control and, consequently, are made with high sensitivity, namely, short proportional band.

The most desirable controller of all for storage-water tanks is the simplest, namely, a sensitive on-off controller, either recording or indicating.

Drier and Carbonizer Temperature. The best instrument for temperature control in driers and carbonizers is a recorder controller providing on-off or narrow-band proportional control. Automatic reset is usually not needed.

Throttling control is not satisfactory if the heater capacity is very great and the temperature is to be held below 212 F. Under these conditions, there may be no pressure head available to operate a steam trap, condensate collects in the heater, and progressive flooding requires the steam pressure to rise in order to transfer the same amount of heat through smaller exposed surface. Eventually, the trap operates and a slug of condensate is blown out. When this happens, high steam pressure is applied to a suddenly enlarged transfer surface. The air temperature surges upward until the controller cuts down the steam pressure again. The same cycle repeats, and it is impossible for steady temperature to be maintained.

An on-off controller overcomes this difficulty by turning the valve full on, blowing out a slug of condensate, and turning the valve full off again as soon as the temperature has started up.

Package Dyeing Machines. Package dyeing machines are commonly being equipped with time-temperature recorder-controllers. The control problem there is technically easy, only narrow-band proportional control being required.

Probably the least recognized critical condition in package dyeing is the liquor flow rate. Most dyers judge the performance of the circulating system by a pressure gage, thinking that high pressure means good exhaust and best uniformity. Actually, pressure at the pump discharge provides a crude and erratic indication of the flow rate.

A direct measurement of flow should actually be used instead

of a pressure measurement. The pressure depends upon various other conditions besides the flow itself. For example, if tight packages are being run, the resistance to flow is higher and the indicated pressure is higher. The circulating flow is actually less than with loose packages, and the results may be less satisfactory in spite of the higher pressure reading.

The importance of high circulating flow cannot be overemphasized. Pressure as such, has no known influence on the dyeing. Conditions should be judged by direct metering of flow, very well accomplished by a rotameter. A flow meter of this type introduces no corrosion problem. It is relatively free from stoppage risk, and stoppages are at once evident. The rotameter introduces the least complication in piping for flow measurement.

Kier Temperature. Bleaching kiers are frequently heated by external steam heaters, with a thermometer bulb in the exit from the heater. Here a proportional controller is always required, usually in combination with a recorder. The necessary proportional band depends upon the heater construction and capacitance.

Scouring-Bowl Temperature. In scouring bowls heated by steam, a proportional controller with narrow or medium proportional band is best, the width of the necessary proportional band depending upon agitation and other conditions influencing uniformity of temperature throughout the liquor and heat transfer to the bulb. In view of customary slow agitation in these bowls, on-off control would be unsatisfactory because of spotty temperature distribution. Self-actuated controllers are less flexible in adjustment to unexpected conditions.

Speed and Tension Control. A much neglected opportunity for profitable application of modern control instruments lies in the field of speed and tension control. Standard instruments made by various manufacturers can be used successfully to improve conditions of speed and tension in traveling materials. It is not necessary to develop special contraptions for those purposes. By straightforward application engineering, a pressure controller, for example, can be adapted to maintain constant tension in a material being wound or unwound.

POWER MEDIUM

The power medium which energizes servocontrollers can be electricity, compressed air, water, oil, or the control agent itself.

Electricity has the advantage of availability. Its chief disadvantage lies in the power unit, which is a solenoid or a motor. Solenoid valves are limited to on-off operation while motor-operated valves suffer from high cost and the overrunning effect of inertia.

The more advanced control effects are less simply and economically introduced in electric control systems than in pneumatic systems. The latter have the advantage of simplicity, ruggedness, ease of understanding by mechanics, and the availability of excellent, low-cost valve power units (diaphragms or pistons). The chief disadvantage of pneumatic controllers is the necessity for a supply of clean dry air.

Hydraulic controls are rugged and reliable, but relatively high in cost. They are not as yet available in indicating and recording instruments.

Self-contained pilot-operated temperature controllers are performing excellently, powered by the pressure of the steam they are controlling. The steam must be thoroughly clean to avoid stoppages in the pilot mechanism.

SPECIAL CONDITIONS

The engineer must always check for special conditions influencing the selection of instruments or control. Questions such as the following should be considered:

1 If control is to be pneumatic or hydraulic, will the air or water supply fail or be shut off at times? Is air or water supply clean enough?

2 If the controller or its power supply should fail, what should the action be to avoid damage or hazard in the process? For example, should a controlled valve be arranged to open, or close, or stay where it is, if the controller fails?

3 If some other element of the operation should fail, is any special response required by the controller? For example, should speed control return to a low-speed position upon stoppage of the machine?

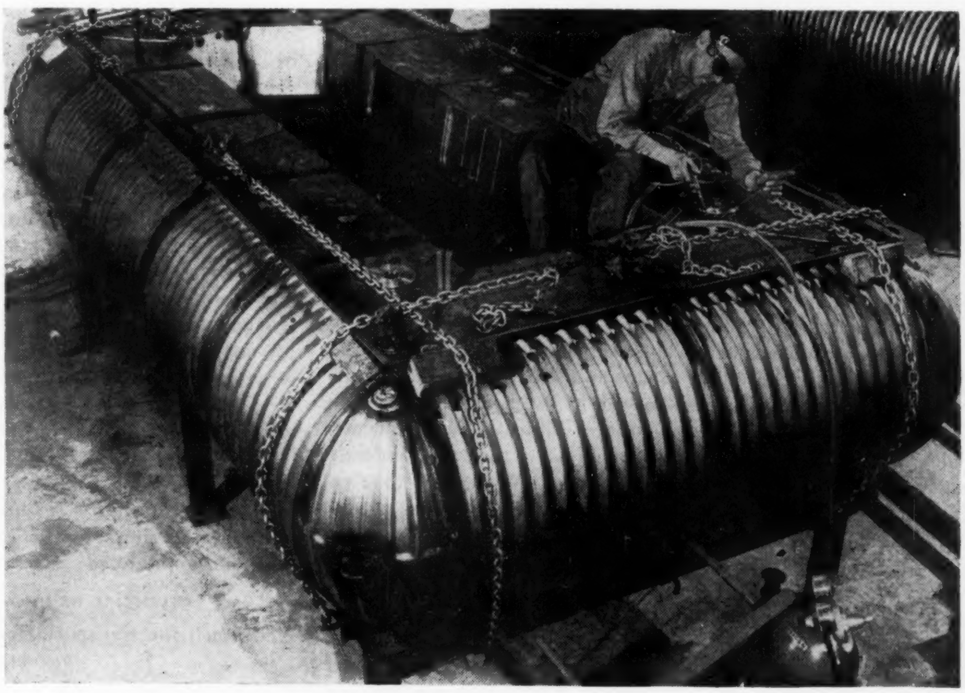
4 Is control point to be changed frequently by the operators, or should setting be done by supervisor only?

5 How important is operation and how reliable must controller be to avoid production tie-ups? Should emergency controls or protective devices be used to back up the primary controller?

6 Will operation function for many years or only a few months?

7 Has the maintenance service sufficient skill to service controllers?

8 What special provisions must be made on account of corrosion conditions?



METAL LIFE RAFT COMPARTMENTED LIKE BATTLESHIP

(In this master jig, the component sections of the life raft are brought together and tack-welded. Here the 14 vertical bulkheads are securely welded and tested for leaks. Courtesy of the Weber Showcase Co.)

WHAT POSTWAR CHINA HOPES FOR FROM U. S. ENGINEERS

By K. Y. CHEN

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ABOUT 100 years ago, in the 1840's, we were brought into closer contact with people of the western world. Our horizon was broadened and we suddenly realized that our national economy based upon agriculture alone and our consumers' goods produced by handicraft alone did not suffice to cope with the new era created by the steam engine.

However, the monarchical government of the old regime was not able to recognize the situation and wasted about 60 years without doing anything worth mentioning. During these 60 years, our neighbor, Japan, was busy building up her industry. By the time the Government of the Republic of China was set up, in 1912, we were again busily engaged in restoring political and economic order from the recently ended revolutionary war, and in suppressing the reactionary elements, one by one throughout the country. Not until 15 years after 1912, i.e., 1927, did the National Government in Nanking begin to put into effect a plan of developing and reconstructing China. There was much to do in a short time. Our enemy, Japan, began to get nervous, seeing the new spirit of the people under the new government and realizing the possibilities of an industrialized China. She began aggression by occupying Manchuria with force in 1931 only four years after the new National Government of the Chinese Republic started to function. From then on Japanese carried on their invasion of Chinese coastal provinces.

Now most of our railways, highways, deep-water routes, and industrial cities are occupied by the enemy. When the enemy is pushed back we are sure that they will demolish or destroy most of the important industries and utilities. So, rehabilitation of the existing industries and cities in China is an important problem to be solved immediately after hostilities cease.

China has been and is basically an agricultural country. In order to keep pace with the rest of the world and raise the economy of her people she is determined to develop her natural resources, improve her agricultural methods, and build up her industry. Industrialization of China after the war is the work in which we need help most from engineers of the United States of America. Before I tell you what you can do in China let me give you some picture of the background, in the following order: (1) Transportation and communication, (2) clothing, food, and housing and, (3) heavy industry.

NEEDS OF TRANSPORTATION AND COMMUNICATION

Transportation is one of the most important industries in any country. According to the latest statistics that I can lay my hands on, the transportation facilities of the major countries of the world are as shown in Table 1.

From this table we notice that the British Isles are best served by railways; for every four square miles there is a mile of railway. Japan proper is best served by highways; for every quarter square mile there is a mile of highway. The British Isles are famous for their shipping industry, for every one-half square mile there are 100 tons of ships. We do not hope to develop Chinese railways, highways, and waterways as extensively as England or the United States. The U.S.S.R. shows in the table as the least developed. If China is to approach the development of the least industrialized of these countries, i.e., U.S.S.R., she would need one mile of railway to each 200 sq miles of territory, and one mile of highway to every 20 sq miles of territory. U.S.S.R. has only 100 tons of ships for every 640 sq miles of territory; however, China has a considerably longer coast line than U.S.S.R. China would need 100 tons of ships to every 100 sq miles of territory. This schedule will call for 22,500 miles of railway, 225,000 miles of highway, and 4,450,000 tons of ships of various kinds. How much does China have now, including occupied areas? She has about 10,000 miles of railways, about 60,000 miles of highways, and about 700,000 tons of ships. So, if we approach a minimum of industrial development, in addition to the rehabilitation of what we have had, we ought to build 12,500 miles of railways, 165,000 miles of highways, and 3,750,000 tons of ships. This is not a large program. It is really a small one. Yet think of the amount of material, equipment, and work that will be required for the job.

TABLE 1 TRANSPORTATION FACILITIES OF MAJOR COUNTRIES

		Square miles served		
		Per mile of railway	Per mile of highway	Per 100 tons of ships
1	U. S. A., continental	11.2	0.98	25.00
2	British Isles	4.0	0.52	0.53
3	France	53.0	0.61	79.50
4	U.S.S.R.	161.0	4.86	640.00
5	Germany proper	5.0	0.69	3.40
6	Japan proper	9.5	0.25	2.90
7	Italy	10.5	0.68	3.60

TABLE 2 NUMBER OF PERSONS SERVED PER TELEPHONE AND MOTOR VEHICLE IN MAJOR COUNTRIES

		Number of persons served per	
		Telephone	Motor vehicle
1	U. S. A., continental	5.7	4.0
2	British Isles	13.8	19.0
3	France	25.8	17.5
4	U.S.S.R.	134.0	161.0
5	Germany proper	18.2	202.0
6	Japan proper	53.0	608.0
7	Italy	61.6	85.0

Now, let's see the number of telephones and motor vehicles we need. Before doing that let's survey the world situation.

From Table 2, we see that the American populace is best served by telephones and motor vehicles. There is a telephone for every six persons, and a motor vehicle for every four persons, while one telephone is serving 134 people in U.S.S.R. and one motor vehicle is serving 608 people in Japan proper. For postwar China, if we were to install one telephone for every 150 people and furnish one motor vehicle for every 1000 people, we would need 3,060,000 telephones and 459,000 motor vehicles. Now, we have in the whole of China not more than 150,000 telephones and 30,000 motor vehicles. So we need about 3 million telephones and half a million motor vehicles. In order to install the telephones, just think of the copper wire needed for such a network. In order to keep these motor vehicles running, just think of the garages and filling stations to be built and maintained.

POTENTIAL DEMAND FOR CONSUMERS' GOODS

So much for transportation and communication. Let's see

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how the consumers' goods stand. Take, for example, cotton cloth. We have almost a half billion people in China. Suppose each of of them needs 10 sq yd of cotton cloth each year; we would have to have 5 billion square yards. Before the war, Chinese-owned mills produced 439,676,000 sq yd and foreign mills in China produced 779,478,000 sq yd, totaling approximately $1^1/_4$ billion square yards. Thus only a quarter of the requirement was supplied by modern spinning and weaving machinery. Taking into consideration the $2^1/_4$ billion square yards produced by hand, we were still short of 1 billion square yards of cotton cloth. So to supply adequate clothing for the Chinese we would need a considerable amount of spinning and weaving machinery in addition to what we have had.

Other kinds of consumers' goods such as woolen, silk, linen and flax, hats, and shoes follow the same pattern.

Being an agricultural country, China must have sufficient food for the whole population. Judging from the records of importation into China of rice and flour, China did not produce enough food. The importation of food into China is nevertheless not due to insufficient production, but chiefly due to lack of transportation. For instance, the cost of rice from Yunnan to Hankow is much higher than that from Indo-China or India; the cost of wheat from Honan to Shanghai is much higher than that from the United States west coast; and in Yunnan province, one year's crop is more than enough for three years' local consumption. However, there is no way to ship this rice to other provinces where there is a famine. When transportation systems in China have been developed, farm machinery has been introduced and manufactured, floods kept under control, irrigation work improved, fertilizer manufacturing plants put into operation, cannery and refrigeration systems developed, I am sure China will have sufficient food for her own people and some for export. There is a lot of work to be done, as you see.

CHINA NEEDS HOUSES

Now we come to the question of housing. Right after the war, most of the displaced populace will return to their homeland and find that their houses have been demolished or destroyed by the war. They must be sheltered. At first we plan to give them temporary sheds with three rooms each built with eight wood posts, nine purlins, simple roof truss, mud walls, and cement floor, the simplest and cheapest building you can think of. If approximately 40,000,000 people need such sheds, we would need 10,000,000 sheds. Each shed needs approximately 200 cu ft of wood and 20 lb of nails and other iron hardware. For this simple project alone, we would need 2,000,000,000 cu ft of wood and 100,000 tons of hardware.

Later on, when living conditions return to normal, more decent and comfortable homes, more public and administrative buildings will be built. Cement factories, brick factories, stone quarries, lumber mills, furniture factories, hardware factories, glass factories, paint factories, and the like, are bound to come to exist in order to supply the natural demand of the people. House appliances such as refrigerators, vacuum cleaners, and washing machines will also come in time. Public utilities, such as city transportation, sewerage, water, lighting, and gas are industries to be developed parallel with housing.

DEVELOPMENT OF HEAVY INDUSTRIES

So far, we have only talked about light industry. Of primary importance, however, are the heavy industries such as coal, oil, steel, power, shipbuilding, and basic machinery. China has plenty of coal. She has discovered oil in Free China. The steel industry is only in its embryonic stage. The United States produces 100,000,000 tons of steel a year, Japan 6,000,000 tons, but China produces less than 100,000 tons—far from sufficient.

Take the building of railways alone. Suppose China has to build the 12,500 miles of railways in the next five years. That would be 2500 miles a year. For each mile of railway a minimum of 200 tons of steel is needed, including rolling stock. Then, for railways alone we would need 500,000 tons of steel per year. In order to supply the necessary rolling stock there must be a locomotive-manufacturing plant big enough to produce 500 locomotives a year and a car plant to provide 5000 freight cars a year. It is unnecessary to enumerate here the various industrial demands we have upon the supply of steel for their development. It would be more than astonishing to imagine for a moment what the present war would be like if there were no steel mills!

THE CENTRAL PLANNING OFFICE

The foregoing gives you a picture of the size of the job for the industrialization of China. For the planning of postwar industrialization of China, our government has set up the Central Planning Office in Chungking, of which Generalissimo Chiang Kai-Shek is chairman. The industries to be developed can be grouped into several categories, as has been discussed.

1 Transportation
  (a) Waterways, shipbuilding
  (b) Railways, locomotive and car manufacturing
  (c) Highways, automobile manufacturing
  (d) Airways, airplane manufacturing
2 Communications
  (a) Telegraph, installing and manufacturing
  (b) Telephone, installing and manufacturing
  (c) Radio, installing and manufacturing
3 Heavy industries
  (a) Power, installing and manufacturing
  (b) Coal mining and petroleum refining
  (c) Metal mining
  (d) Iron and steel industry
  (e) Basic machinery manufacturing
  (f) Heavy chemical industry
4 Light industries
  (a) Clothing, woolen, silk, cotton, linen, fur, hats, shoes
  (b) Food, cannery, refrigeration, fertilizer, implements, flood control and irrigation, etc.
  (c) Building, cement, brick, wood mill, furniture making, hardware, utensils, house appliances, utilities

China is so big and the industries to be developed are so many that the Central Planning Office will have to study and ascertain what kinds of industries are most suitable to certain localities, taking into consideration such factors as (1) supply of raw materials, (2) supply of manpower, (3) facilities for transportation, and (4) outlook for expansion. Formerly, Chinese industries were concentrated in coastal regions. Because of that they were easily destroyed or occupied by the enemy and at the same time the interior was neglected. The present consensus of economists, industrialists, and government authorities is to divide China into regions of industrial development. Certain industries may be established in all of these regions; certain industries may be located in one or two regions only. Obviously, the object of this division of region is to utilize to the fullest extent the local material and labor, to increase working efficiency, to improve quality of products, to reduce the cost of production, to minimize the cost of transportation, and, above all, to lessen the horror of destruction by enemy invasion.

The program is going to be big and the work is going to be tremendous; so big and so tremendous that an ordinary layman will not be able to grasp the idea or to see the whole picture. In order to carry out such a gigantic project, we shall have to have (1) raw materials, (2) labor, (3) capital, and (4) technical skill. We have an abundance of raw materials and manpower. What we are in need of and hope for from our friendly nations are capital and technical skill.

"International Development of China" is our national policy formulated by the founder of our Republic, Dr. Sun Yat-Sen, and adopted by our President Chiang Kai-Shek. Your fore-

fathers built your country by loans or capital investments from Europe. Your good work has paid your debts and has built up the richest and strongest nation of the world. China has enormous resources. If she can interest capital, she, too, can develop her industries. At the beginning of her industrialization, she will pay her loans by her usual export of raw materials such as tungsten, tin, antimony, silk, tea, tung oil, and some other farm products. She can also pay a part of her debts by exporting products of handicrafts such as embroideries, rugs, chinaware, lacquer goods, ivory articles, jewelry. Later on, when the finished products roll out, they will be exported to pay her debts. Loans or capital investments may be in the form of material, machinery, or equipment. For this war, billions of dollars and pounds have been spent to establish new manufacturing plants in the United States and in England. After the war, these new facilities are bound to lie idle and deteriorate. Your statesmen, economists, and industrialists are now busily engaged in investigating and planning the postwar utilization of such a tremendous amount of machinery and equipment. Well, here is one of the possible solutions. They can be sold or loaned to China, serving as a basis for building up her industry. We will leave the details of such capital or investment to the financial experts.

For the postwar industrial reconstruction of China, our government has adopted the policy of emphasizing the simultaneous development of state and private industry. Industries which the government considers less suitable for the state to operate will be privately operated. In order to show a spirit of close co-operation with our friendly powers, all restrictions applying to Chinese foreign joint enterprises have been revised. First, no fixed restriction is now placed on the ratio of foreign capital investment in joint enterprises. Second, in the organization of a Chinese foreign joint enterprise, except for the chairman of the board of directors, the general manager need not be a Chinese. Third, aliens, in accordance with the provisions of Chinese law and regulations, who have received the sanction of the Chinese Government, may finance their own enterprises in China. With these provisions promulgated, the purchasing power of 450,000,000 people restored and elevated, and transportation and communication systems installed, foreign private investments in China will be sound, safe, and mutually beneficial.

THE PROBLEM OF TECHNICAL SKILL

Now we come to the problem of technical skill. About one quarter of the world's population in China, which has an abundance of natural resources and energy, is barely subsisting. Engineers are those who utilize their knowledge of nature, and their experience in handling materials, to convert natural resources and energy into products, power, and wealth, for the benefit of all mankind, thereby raising the standard of living of everybody. In China, we have a big job to do. Engineers are the men to do it. In the first ten years of Chinese industrialization our President, Chiang Kai-Shek, in his book, "Destiny of China," calls for $2^1/_2$ million engineers and points out that in the last five years graduates from technical and vocational schools totaled only half a million. In order to carry on our work, we need a total of 2,000,000 more engineers. However, the new graduates certainly cannot shoulder the responsibility of the gigantic job of industrialization. The only possibility of carrying on this work is to invite to China engineers of achievement and of high experience who will design, install, operate, manage, and develop our machineries of production.

China used to buy most finished products from the outside world. Whenever hostilities arise somewhere in the world, the whole structure of supply is changed. If all the supply lines are cut as is true now in China, hardly any of the finished products so desperately needed can be obtained. One of the prominent Chinese in Washington once said, "We used to depend upon imported eggs to live. If the supply line is cut, we cannot get any more eggs. Hereafter, we have to import and learn to raise chickens in order to insure our supply of eggs." This figure of speech illustrates very clearly and vividly our present situation. So, in the program of postwar reconstruction and industrialization of China, we will import more basic machineries than finished products.

Before the war, when machinery and equipment were imported into China, price was the controlling factor. Therefore the cheaper products only were imported. The result is we have so many makes and types of equipment that we have a hard time keeping a stock of spare parts. Now is the golden time to standardize machinery and equipment. Once standardized, the same type of machine or equipment will be imported. When the manufacturing plants in China, either Chinese owned or Chinese and foreign owned, are able to produce enough to meet the demand, the same type of machine or equipment will be manufactured in large scale. It is up to the engineers of today to design machinery and equipment in such a way that they are simple, rugged, easy to operate, reasonably accurate, and efficient, and, above all, of low cost, and to try to convince the Chinese authorities to adopt their design as standard.

Training of additional engineers by our guest engineers is one of the prerequisites of this gigantic program. Chinese engineers trained in this country and in Europe are now most influential and many of them are holding important positions in various industries in China. Yet the number available is very limited. Mass-production programs of technical training will have to be devised and carried out immediately.

There are two ways of carrying out the program of training: (1) By sending trainees over to this country, and (2) by inviting experienced engineers to China as instructors. We have already several hundreds of young men in this country being trained. When they go back to China they have to perform several duties at the same time—to render the service they are specialized in, to teach others "know how," to be supervisors, and later to be managers. In your shops or in your factories, you must have met some of them. They are eager and serious because they know they have a job to do. When they are through with their training in your country, they will be familiar with the construction, installation, and maintenance of your machines and they are going to be the best salesmen of your products in China. But this method can be used only for training top men; it cannot be carried out on a big scale. We shall invite experienced engineers in many different fields to China to train young engineers to carry on the work of rehabilitation and reconstruction.

The importance of foremen and technicians cannot be overemphasized. At least 10,000,000 skilled men must be trained. You people are worrying about postwar unemployment and finding jobs for your boys coming home, while we Chinese will have so many industries to be developed and will have a hard time finding the experienced men to work.

Another field of activity for engineers in the program of postwar industrialization of China is the field of research which will seek the utilization of the native raw materials to meet the basic needs, such as the manufacture of plastics from rice stalks, wheat stalks, and soybeans, and which will explore more of iron and coal mines, other metallic mines, and oil fields with a view to producing more and more for our people of China and our good neighbors whom we wish to live and trade with.

I have given you some background of Chinese industry and a glimpse of future programs of the rehabilitation and industrialization of the country. You can see now what postwar China hopes for from you engineers. Your forefathers found opportunities in the West and built up a beautiful and powerful country. I have barely touched upon the opportunities that will be opened for you in the Far East. Let us work together and build up another beautiful and powerful country in the Far East, write another period of prosperity in Chinese history, and, above all, maintain an everlasting peace for the whole world, enabling the whole population of the world to live sufficiently and contentedly as the Chinese of past generations.

The Unwritten

LAWS *of* ENGINEERING

Part 3—Purely Personal Considerations for Engineers

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THE importance of the personal and sociological aspects of our behavior as engineers is brought out in the following quotation (1):[1]

"In a recent analysis of over 4000 cases, it was found that 62 per cent of the employees discharged were unsatisfactory because of social unadaptability, only 38 per cent for technical incompetence."

And yet about 99 per cent of the emphasis in the training of engineers is placed upon purely technical or formal education. In recent years, however, there has been a rapidly growing appreciation of the importance of "human engineering," not only in respect to relations between management and employees but also as regards the personal effectiveness of the individual worker, technical or otherwise. It should be obvious enough that a highly trained technological expert with a good character and personality is necessarily a better engineer and a great deal more valuable to his company than a sociological freak or misfit with the same technical training. This is largely a consequence of the elementary fact that in a normal organization no individual can get very far in accomplishing any worth-while objectives without the voluntary co-operation of his associates; and the quantity and quality of such co-operation is determined by the "personality factor" more than anything else.

This subject of personality and character is, of course, very broad and much has been written and preached about it from the social, ethical, and religious points of view. The following "laws" are drawn up from the purely practical point of view based upon well-established principles of "good engineering practice," or upon consistently repeated experience. As in the preceding sections, the selections are limited to rules which are frequently violated, with unfortunate results, however obvious or bromidic they may appear.

"LAWS" OF CHARACTER AND PERSONALITY

One of the most important personal traits is the ability to get along with all kinds of people. This is rather a comprehensive quality but it defines the prime requisite of personality in any type of industrial organization. No doubt this ability can be achieved by various formulas, although it is probably based mostly upon general, good-natured friendliness, together with fairly consistent observance of the "Golden Rule." The following "do's and don'ts" are more specific elements of such a formula:

1 Cultivate the tendency to appreciate the good qualities, rather than the shortcomings of each individual.

2 Do not give vent to impatience and annoyance on slight provocation. Some offensive individuals seem to develop a striking capacity for becoming annoyed, which they indulge with little or no restraint.

3 Do not harbor grudges after disagreements involving honest differences of opinion. Keep your arguments on an objective basis and leave personalities out as much as possible.

4 Form the habit of considering the feelings and interests of others.

5 Do not become unduly preoccupied with your own selfish interests. It may be natural enough to "look out for Number One first," but when you do your associates will leave the matter entirely in your hands, whereas they will be much readier to defend your interests for you if you characteristically neglect them for unselfish reasons.

This applies particularly to the matter of credit for accomplishments. It is much wiser to give your principal attention to the matter of getting the job done, or to building up your men, than to spend too much time pushing your personal interests ahead of everything else. You need have no fear of being overlooked; about the only way to lose credit for a creditable job is to grab for it too avidly.

6 Make it a rule to help the other fellow whenever an opportunity arises. Even if you're mean-spirited enough to derive no personal satisfaction from accommodating others it's a good investment. The business world demands and expects co-operation and teamwork among the members of an organization. It's smarter and pleasanter to give it freely and ungrudgingly, up to the point of unduly neglecting your own responsibilities.

7 Be particularly careful to be fair on all occasions. This means a good deal more than just being fair, upon demand. All of us are frequently unfair, unintentionally, simply because we do not habitually view the matter from the other fellow's point of view, to be sure that his interests are fairly protected. For example, when a man fails to carry out an assignment, he is sometimes unjustly criticized when the real fault lies with the executive who failed to give him the tools to do the job. Whenever you enjoy some natural advantage, or whenever you are in a position to injure someone seriously, it is especially incumbent upon you to "lean over backwards" to be fair and square.

8 Do not take yourself or your work too seriously. A normal healthy sense of humor, under reasonable control, is much more becoming, even to an executive, than a chronically soured dead-pan, a perpetually unrelieved air of deadly seriousness, or the pompous solemn dignity of a stuffed owl. The Chief Executive of the United States smiles easily or laughs heartily, on appropriate occasions, and even his worst enemies do not attempt to criticize him for it. It is much better for your blood pressure, and for the morale of the office, to laugh off an awkward situation now and then than to maintain a tense tragic atmosphere of stark disaster whenever matters take an embarrassing turn. To be sure, a serious matter should be taken seriously, and a man should maintain a quiet dignity as a rule, but it does more harm than good to preserve an oppressively heavy and funereal atmosphere around you.

9 Put yourself out just a little to be genuinely cordial in greeting people. True cordiality is, of course, spontaneous

[1] Numbers in parentheses refer to the Bibliography at the end of the paper.

NOTE: Parts 1 and 2 of this series appeared on pages 323 and 398, of the May and June issues of MECHANICAL ENGINEERING, respectively.

and should never be affected, but neither should it be inhibited. We all know people who invariably pass us in the hall or encounter us elsewhere without a shadow of recognition. Whether this be due to inhibition or preoccupation we cannot help feeling that such unsociable chumps would not be missed much if we never saw them again. On the other hand, it is difficult to think of anyone who is too cordial, although it can doubtless be overdone like anything else. It appears that most people tend naturally to be sufficiently reserved or else over-reserved in this respect.

10 Give the other fellow the benefit of the doubt if you are inclined to suspect his motives, especially when you can afford to do so. Mutual distrust and suspicion breed a great deal of absolutely unnecessary friction and trouble, frequently of a very serious nature. This is a very common phenomenon, which can be observed among all classes and types of people, in international as well as local affairs. It is derived chiefly from misunderstandings, pure ignorance, or from an ungenerous tendency to assume that a man is guilty until he is proved innocent. No doubt the latter assumption is the "safer" bet, but it is also true that if you treat the other fellow as a depraved scoundrel, he will usually treat you likewise, and he will probably try to live down to what is expected of him. On the other hand you will get much better co-operation from your associates and others if you assume that they are just as intelligent, reasonable, and decent as you are, even when you know they're not (although the odds are 50:50 that they are). It isn't a question of being naïve or a perpetual sucker; you'll gain more than you lose by this practice, with anything more than half-witted attention to the actual odds in each case.

Do not be too affable. It's a mistake, of course, to try too hard to get along with everybody merely by being agreeable and friendly on all occasions. Somebody will take advantage of you sooner or later, and you cannot avoid trouble simply by running away from it ("appeasement"). You must earn the respect of your associates by demonstrating your readiness to give any man a hell of a good fight if he asks for it. Shakespeare put it succinctly in Polonius' advice to his son (in "Hamlet"): "Beware of entrance to a quarrel; but being in, bear it that the opposed may beware of thee."

On the other hand, do not give ground too quickly just to avoid a fight, when you know you're in the right. If you can be pushed around easily the chances are that you will be pushed around. There will be times when you would do well to start a fight yourself, when your objectives are worth fighting for.

As a matter of fact, as long as you're in a competitive business you're in a fight all the time. Sometimes it's a fight between departments of the same company. As long as it's a good clean fight, with no hitting below the belt, it's perfectly healthy. But keep it on the plane of "friendly competition" as long as you can. (In the case of arguments with your colleagues, it is usually better policy to settle your differences out of court, rather than to take them to the boss for arbitration.)

Likewise, in your relations with subordinates it is unwise to carry friendliness to the extent of impairing discipline. There are times when the best thing that you can do for a man (and the company) is to fire him, or transfer him. Every one of your men should know that whenever he deserves a good "bawling out" he'll get it, every time. The most rigid discipline is not resented so long as it is reasonable, impartial, and fair, especially when it is balanced by appropriate rewards, appreciation, and other compensations as mentioned in Part 2. Too much laxity or squeamishness in handling men is about as futile as cutting off a dog's tail an inch at a time to keep it from hurting so much. If you do not face your issues squarely, someone else will be put in your place who will.

Regard your personal integrity as one of your most important assets. In the long pull there is hardly anything more important to you than your own self-respect and this alone should provide ample incentive to maintain the highest standard of ethics of which you are capable. But, apart from all considerations of ethics and morals, there are perfectly sound hardheaded business reasons for conscientiously guarding the integrity of your character.

One of the most striking phenomena of an engineering office is the transparency of character among the members of any group who have been associated for any length of time. In a surprisingly short period each individual is recognized, appraised, and catalogued for exactly what he is, with far greater accuracy than that individual usually realizes. This is true to such a degree that it makes a man appear downright ludicrous when he assumes a pose or otherwise tries to convince us that he is something better than he is. As Emerson puts it: "What you are speaks so loud I cannot hear what you say." In fact it frequently happens that a man is much better known and understood by his associates, collectively, than he knows and understands himself.

Therefore, it behooves you as an engineer to let your personal conduct, overtly and covertly, represent your conception of the very best practical standard of professional ethics, by which you are willing to let the world judge and rate you.

Moreover, it is morally healthy and tends to create a better atmosphere, if you will credit the other fellow with similar ethical standards, even though you may be imposed upon occasionally. The obsessing and overpowering fear of being cheated is the common characteristic of second- and third-rate personalities. This sort of psychology sometimes leads a man to assume an extremely "cagey" sophisticated attitude, crediting himself with being impressively clever when he is simply taking advantage of his more considerate and fair-minded associates. On the other hand a substantial majority of top-flight executives are scrupulously fair, square, and straightforward in their dealings with all parties. In fact most of them are where they are largely because of this characteristic, which is one of the prime requisites of first-rate leadership.

The priceless and inevitable reward for uncompromising integrity is confidence, the confidence of associates, subordinates, and "outsiders." All transactions are enormously simplified and facilitated when a man's word is as good as his bond and his motives are above suspicion. Confidence is such an invaluable business asset that even a moderate amount of it will easily outweigh any temporary advantage that might be gained by sharp practices.

Integrity of character is closely associated with sincerity, which is another extremely important quality. Obvious and marked sincerity is frequently a source of exceptional strength and influence in certain individuals, particularly in the case of speakers. Abraham Lincoln is a classic example. In any individual, sincerity is always appreciated, and insincerity is quickly detected and discounted.

In order to avoid any misunderstanding, it should be granted here that the average man, and certainly the average engineer, is by no means a low dishonest scoundrel. In fact the average man would violently protest any questioning of his essential honesty and decency, perhaps fairly enough. But there is no premium upon this kind of common garden variety of honesty, which is always ready to compromise in a pinch. The average man will go off the gold standard or compromise with any sort of expediency whenever it becomes moderately uncomfortable to live up to his obligations. This is hardly what is meant by "integrity," and it is certainly difficult to base even a moderate degree of confidence upon the guarantee that you will not be cheated unless the going gets tough.

A little profanity goes a long way. Engineering is essentially a gentleman's profession, and it ill becomes a man to carry profanity to the point of becoming obnoxiously profane. Unfortunately, profanity is sometimes taken as a mark of rugged

he-man virility, but any engineer with such an idea should realize that many a pimply, half-witted, adolescent street urchin will hopelessly outclass him in this respect.

On the other hand, there is no reason why a man should be afraid to say "damn." On appropriate occasions a good hearty burst of colorful profanity may be just a healthy expression of strong feelings. But there is never any occasion for the filthy variety of obscenity, and a really foul mouth will generally inspire nothing but contempt.

Be careful of your personal appearance. Roughly eight out of every ten engineers pay adequate attention to their personal appearance and neatness. The other two offend in respect to one or more of the following items:

1 Suit rumpled or soiled, or else trousers, coat, and vest have nothing in common but their means of support.

2 Shoes, unpolished or dilapidated.

3 Tie, at half-mast or looking like it was tied with one hand. Some individuals seem to own but one tie, which takes an awful beating. Others wear colors contrasting violently with suit or shirt, but this is sometimes a matter of artistic license (if it isn't color blindness).

4 Shirt, frayed at collar or cuffs, or just plain dirty.

5 Hands, dirty.

6 Nails, in deep mourning, chewed off, or else absurdly long. A man doesn't need to be fastidious, but dirty neglected nails immediately and conspicuously identify a careless sloppy individual. (This is especially true in the case of an interview, where first impressions are so important.)

Of course we all know some very good men who are oblivious to such details, so that it cannot be said that all who ignore them are necessarily crude, third-rate, slovenly low-brows, but it is probably a safe bet that all crude, third-rate, slovenly low-brows are offensive in most of these respects.

Do not argue that you cannot afford to look your best; you cannot afford not to. Your associates and superiors notice these details, perhaps more than you realize, and they rate you accordingly.

In this connection, note the following quotation from a recent pamphlet on "employee rating" (2):

"The 'halo effect' simply means that rating of one trait is often influenced by that given to some other trait. Thus an employee who makes a nice appearance and has a pleasant manner is apt to obtain a higher rating on all other traits than he deserves."

Analyze yourself and your men. In the foregoing, it has been assumed that any normal individual will be interested in either:

(*a*) Advancement to a position of greater responsibility, or

(*b*) improvement in personal effectiveness as regards quantity and/or quality of accomplishment.

Either of these should result in increased financial compensation and satisfaction derived from the job.

With reference to item (*a*), it is all too often taken for granted that increased executive and administrative responsibility is a desirable and appropriate form of reward for outstanding proficiency in any type of work. This may be a mistake from either of two points of view:

1 The individual may be very much surprised to find that he is much less happy in his new job than he thought he was going to be. In many instances young engineers are prone to assume that increased responsibility means mostly increased authority and compensation. Actually, the term "compensation" is well applied, for the extra salary is paid primarily to compensate for the extra burden of responsibility. Of course most people relish the added load, because of the larger opportunities that go with it, but many perfectly normal individuals find it more of a load than anything else. It is not uncommon for an engineer or a scientist to discover, to his dismay, that as soon as he becomes an executive he no longer has time to be an engineer or a scientist. In fact, some executives have time for absolutely nothing else.

2 From the business standpoint, it by no means follows that because a man is a good scientist, he will make a good executive. Many a top-notch technician has been promoted to an administrative position very much to his own and the job's detriment.

These facts should therefore be considered carefully by the man threatened with promotion and by the man about to do the promoting. There are other ways of rewarding a man for outstanding accomplishment.

It is not always easy, however, to decide in advance whether you, or the man in question, would be happier and more effective as an executive or as an individual worker. There is no infallible criterion for this purpose but it will be found that, in general, the two types are distinguished by the characteristics and qualities listed in Table 1.

TABLE 1 CHARACTERISTIC QUALITIES FOR EXECUTIVE OR INDIVIDUAL WORKERS

Executive	Individual worker
Extrovert	Introvert
Cordial, affable	Reserved
Gregarious, sociable	Prefers own company
Likes people	Likes technical work
Interested in people	Interested in mechanisms, ideas
Interested in:	Interested in:
Business	Sciences
Costs	Mathematics
Profit and loss	Literature
Practices	Principles
Ability to get many things done	Ability to get intricate things done
Practical	Idealistic
Extensive (broad perspectives)	Intensive (penetrating)
Synthesist	Analyst
Fast, intuitive	Slow, methodical
Talent for leadership	Independent, self-sufficient
Uses inductive logic	Uses deductive logic
Has competitive spirit	Prefers to "live and let live"
Bold	Modest
Courageous	Retiring
Noisy	Quiet
Aggressive	Restrained
Tough, rugged	Vulnerable, sensitive
Confident	Deferential
Impulsive	Intellectual
Vigorous, energetic	Meditative, philosophical
Opinionated, intolerant	Broad-minded, tolerant
Determined	Adaptable
Impatient	Patient
Enterprising	Conservative

Of course many people represent intermediate types, or mixtures; the attributes given in Table 1 delineate the pronounced types. Nevertheless, if most of your attributes lie in the right-hand column the chances are very much against your becoming a successful executive. On the other hand, if you are interested primarily in increasing your effectiveness as an individual worker you would do well to develop some of the strong qualities listed in the left column, to reinforce the virtues on the right.

Two facts stand out sharply in this connection:

1 Whatever your position, and however complacent you may be about it, there is always room for improving your effectiveness; usually plenty of room.

2 Whatever your natural handicaps may be, it is always possible to accomplish such improvement by study and practice, provided only that you have the will, the determination, and the interest to sustain the effort.

It is very much like the design of a piece of apparatus. Any experienced engineer knows that it is always possible to secure substantial improvements by a redesign. When you get into it you will find that there are few subjects more absorbing or more profitable than the design and development of a good engineer! As Alexander Pope wrote many years ago:

"The proper study of mankind is man."

As previously suggested, this applies to the development of your men as well as yourself. It likewise applies to the ap-

praisal and selection of men. After your own character, the next most important factor in your ultimate success is the caliber of your assistants. In fact, there are, doubtless, cases where the character of the executive is not particularly important, provided only that he is smart enough to surround himself with top-notch men to carry the load. In many instances the success or failure of your business will depend upon whether your engineers are slightly above or below the marginal level of competence for the industry.

It is a significant fact that, in the overwhelming majority of cases, the decisive differences in the abilities of engineers are relatively small. In spite of the occasional incidence of a genius or a nit-wit, the great majority of personnel in any industry and the backbone of the large organizations are individuals who vary only slightly from the norm. In general, when executives look over an organization to select a man for a better job, those who are passed up have very few actual shortcomings, but the man who is chosen has the least. Likewise, many top executives are distinguished not so much by marked genius as by relative freedom from defects of character. There is nowhere near enough genius to go around.

This should be particularly heartening to the younger men who view the leaders of industry with awe and wonder upon what meat they feed. Nine out of ten of you have "what it takes" as regards native endowments. The problem is to make the most of what you have.

To this end it will be helpful to study some of the employee rating sheets and charts that have been evolved by various industries. Sample forms and a general discussion of the subject will be found in the pamphlet on "employee rating" (2). It is very noticeable that most of these forms are concerned chiefly with acquired rather than inherited traits. The point is that most of the features upon which individuals are rated represent bad habits or plain ignorance, i.e., features that may be controlled and corrected by conscious effort.

CONCLUSION

The foregoing "laws" represent only one basic element in the general formula for a successful engineering career. The complete list of essential components is as follows:

(*a*) The written laws (the arts and sciences).

(*b*) The unwritten laws, of which the foregoing is admittedly no more than a preliminary and very inadequate summary.

(*c*) Native endowments (intelligence, imagination, health, energy, etc.).

(*d*) Luck, chance, opportunities ("the breaks").

The last item is included because good or bad fortune undoubtedly enters into the picture occasionally. Broadly speaking, however, luck tends to average out at a common level over a period of years, and there are more opportunities looking for men than there are men looking for opportunities.

About all that we can do about our native endowments is to conserve, develop, and utilize them to best advantage.

The "unwritten laws," including those that are still unwritten, are needed to give direction to our efforts in this latter respect.

The "written laws" receive plenty of attention during our formal schooling, but our studies are not always extended as effectively as they might be after graduation. In many cases, superior technical knowledge and training represents the marginal consideration in the selection of men for key positions.

To anyone interested in improving his professional effectiveness, further study of both types of laws will yield an excellent return on the investment. Under present conditions, however, most engineering graduates are much closer to the saturation point in respect to the written than to the unwritten variety. A few references are listed in the Bibliography for the benefit of those who may be interested in further excursions into these subjects.

Finally it should be observed that the various principles which have been expounded, like those of the arts and sciences, must be assiduously applied and developed in practice if they are to become really effective assets. It is much easier to recognize the validity of these "laws" than it is to apply them consistently, just as it is easier to accept the doctrines of Christianity than to practice them. The important thing here is to select, in so far as possible, a favorable atmosphere for the development of these professional skills. This is undoubtedly one of the major advantages of employment in a large engineering organization, just as it is advantageous to a young doctor to spend his internship in the Mayo Clinic. Perhaps even more important, as previously mentioned, is the selection of your boss, particularly during those first few years that constitute your engineering apprenticeship. No amount of precept is as effective as the proper kind of example. Unfortunately, there is not nearly enough of this kind of example to go around, and in any event it will behoove you to study the "rules of the game" to develop your own set of principles to guide you in your professional practice.

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METHODS IMPROVEMENT

From the Viewpoint of the Consultant

By HAROLD B. MAYNARD

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THE strength of any nation or of any group within a nation lies in its ability to produce. In time of war, production furnishes the weapons of defense and offense which are needed to bring the conflict to a successful conclusion. In time of peace, production furnishes the material goods which contribute toward a high standard of living.

Production is the basis for general material well being in normal times. Although there may always be a great deal of controversy concerning the proper procedure for distributing what is made, under any plan which may be advanced, whether it be called "capitalism," "socialism," "communism," or any other ism, the fact remains that we can have only what we produce. To have more, we must produce more. To have the leisure to enjoy it, we must learn to produce it in less time.

These simple statements of fact form the basis for the creed of the methods engineer. They constitute the force which motivates him to seek ever better ways of producing. He so thoroughly believes that his work is important and of real benefit to all sections of our social group, that he is impelled to press on with methods-improvement work in spite of the obstacles which are invariably encountered.

In speaking of the methods engineer, it should be made clear that it is not the intention to imply that all methods improvements are or should be made by him. This term is used merely to personify a point of view, an attitude of dissatisfaction with fatiguing, ineffective ways of producing, of a constant will to do things a little better tomorrow than they were done yesterday, and of a never ending searching for better methods of accomplishment. Anyone who has this point of view will carry on methods-improvement work whether he is classified as a member of management, labor, government, or any other group. In a functionalized industrial organization, the task of co-ordinating all methods-improvement activities is customarily assigned to the methods engineer—although not always under this exact title—and the term is therefore used to represent the visible human symbol of a basic philosophy.

Although a considerable technique has been developed for improving methods, success in methods-improvement work may be achieved quite simply. All that is necessary, fundamentally, is a real desire to make improvements. With that as a foundation from which to start, the methods-engineering procedure resolves itself into the systematic application of common sense.

Unfortunately, not everyone desires to improve. It has been said many times that it is human nature to resist change. Indeed history discloses a long record of almost constant resistance to new methods as mankind has struggled up the path of civilization. Fortunately there have always been a few progressive individuals in all times who have wanted better easier ways of doing things. Their influence has been strong enough to overcome resistance to change and to guide us slowly with frequent stops and even retrogressions toward a fuller material life.

Nearly everyone who undertakes methods-improvement work in present-day industry is impressed with the almost limitless opportunities for improvement which exist. When the methods engineer observes industrial operations with an open mind, and, applying the Questioning Attitude, asks why, how, what, where, when, and who, he finds that operation after operation can be improved. By aggressively undertaking to make changes, he usually succeeds in making some truly remarkable improvements. Yet from his own viewpoint, the improvements which are made are such a small portion of those which could be made that he often feels a sense of frustration in his work.

METHODS ENGINEERING NOT-GENERALLY UNDERSTOOD

Because this is a common experience, it will be worth while to attempt to discover by analysis some of the obstacles which lie in the way of methods improvement. First in importance appears to be a general lack of understanding of the work of the methods engineer. Methods engineering is not an easy subject to grasp, for it has many ramifications. It cannot be completely described in a few simple words or catchy phrases.

Therefore, in the management field, men with a sales or an engineering background tend to regard methods engineering as a necessary but boringly detailed clerical task like accounting, and thus do not give the procedure the full support it must have.

Lack of understanding of methods engineering also exists in the ranks of labor. This manifests itself most commonly in a misunderstanding of the purposes of the work. It is often thought that the purpose of the work is to speed up the worker and to make him produce more through greater physical effort. The basis for this goes back to the "efficiency-expert" era of twenty-five years ago when certain inexpert experts were indeed guilty of this practice. Present-day methods engineers must recognize the scars left from this period and must, by patiently demonstrating again and again that they are seeking production increases through the development of easier less fatiguing methods, try to win the confidence of those with whom they are working in the fairness of their procedures.

With regard to the attitude of the general public toward methods improvements, it appears to be highly inconsistent. The same public which welcomes methods improvements when they appear in the form of reduced prices for consumer goods allows the ban on the use of time studies in government installations to be repassed year after year by its chosen representatives with each new appropriations bill. By this, it encourages inefficiencies for which it must pay from its own collective pocket. Undoubtedly the reason for this is again lack of understanding. When it is generally understood that methods-improvement work is not another form of speedup and that its application to government activities will result in better services, a stronger nation, and lower taxes, then we can expect a change in this obsolete law. Until that time, we can expect many people to agree with the thinking which summarizes its feelings with the statement: "The trouble with us is that we have too many machines." Although the fallacy of this thinking has been exposed again and again by both management and labor leaders, it is still a popularly held notion among a large section of the public.

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In addition to lack of understanding, an important obstacle to methods improvement is the previously mentioned human tendency to resist change. Although this may be less commonly encountered in the management group than in any other segment of society, nevertheless management, which is only a name for a group of human beings, does at times resist change. The resistance may be due to several causes. It may be due to a lack of understanding of what the methods engineer proposes as has already been pointed out. It may be caused by satisfaction with past accomplishments or the status quo. It may be engendered by a fear of criticism for not having made the improvements long ago. It may result from a fear of change, apprehension over its possible effect on labor attitudes, quality, or supervisory problems. Or it may merely be caused by an emotional bias, by a clash of personalities, or by any of the thousand and one other things which cause human beings to act irrationally at times. In any event, resistance to change on the part of management is a factor which must be considered in undertaking any methods-improvement activity.

Resistance to change is also encountered on the part of the worker. In addition to his natural human dislike of change, he often feels that his personal security is threatened when a methods improvement is made. No man can be expected willingly to go along with a change which will put him out of a job. Even though he knows that the end result of better methods is greater material prosperity and greater leisure, he does not want the greater prosperity to go to others through the sacrifice of his own pay envelope nor does he wish the added leisure to be centered in himself in the form of unemployment. Hence instead of considering the worker reactionary if he resists change, the qualified methods engineer will recognize the cause, and by practicing the golden rule and doing his work as he would wish to have it done if the position were reversed, will endeavor to introduce improved methods without threatening the security of the individual.

OTHER FACTORS RETARDING METHODS-IMPROVEMENT WORK

In addition to lack of understanding and human resistance to change, three other factors have been observed in industry which tend to retard methods-improvement work. First the methods-engineering function is often placed at too low a level in the organization. This is probably due to a lack of recognition of the importance of the function. If a skilled methods engineer is regarded as merely a high-grade clerk, and if he is placed in a position of being responsible to a foreman with a limited desire to progress, it definitely reduces his effectiveness. Under such circumstances, the more ambitious men move on, leaving only those who are satisfied to stay for the sake of the weekly pay check.

The second factor consists of a general tendency to underpay methods engineers. This is particularly serious at the present time, due to the fact that the earnings of hourly rated employees with incentives and overtime bonus have tended to rise faster than salaries. Even within the salary group, however, the relationship of the pay of a methods man to the pay of other high-grade salary jobs is often incorrect. When, because of salary scales, a change from methods engineer to assistant foreman represents a promotion, it is evident that the scales are incorrect. The result, of course, is that the better men gravitate away from methods work.

Finally there is an almost universal tendency to understaff the methods department. Any methods man worthy of the name will earn his salary many times over each year through the operating economies which he effects. At the same time, accounting practices place the salary of methods engineers prominently in the overhead account. The savings which they make are buried in cost records. This results in a tendency to regard methods engineering as overhead to be controlled by a budget in the same manner as any other item of expense. When business volume falls off, the methods-engineering staff is reduced to "save expense." Thus the possibility for securing operating economies is reduced at a time when they are needed the most. When volume increases, on the other hand, there is a reluctance to increase the size of the methods department in proportion. In many organizations, it is a simple matter to obtain approval for the expenditure of say $3000 for a machine because it will return $600 a year in savings, but it is an entirely different matter to obtain approval for the addition of a methods engineer to the staff when the same investment might return $25,000 in the same period.

The three factors may be readily corrected by any management which agrees with the analysis just made.

The other two obstacles, lack of understanding and resistance to change, are more difficult to overcome. The professional methods engineer has been keenly aware of these two problems for some time and has been endeavoring to develop solutions for both. As a matter of fact, considerable progress has been made. In connection with the first point, educational activities in the field of methods engineering have been expanding rapidly. Through universities, through consultants, through government-sponsored training programs, education has been going on apace at all levels of industrial organization. Books and magazine articles have increased, and programs of professional societies on this subject are being held in increasing numbers. In fact so great has been the acceleration in recent months that the 10-year report of progressin this field presented by the author at the annual meeting of The American Society of Mechanical Engineers in December of 1942 already seems out of date.

Although no way has yet been discovered of overcoming the human tendency to resist change, methods engineers are attacking the problem by developing procedures which will eliminate much of the necessity for change. There is a large classification of change which is not necessary or at least which can be avoided. In this classification lie the changes which are made to correct conditions or practices which never should have been allowed to exist in the first place. Many of the methods changes which are made in industry belong in this category. They cause major problems in industrial relations and constitute an important obstacle in the path of effective production. Although it would be impractical to expect that every new job could be introduced into the shop in a state of unassailable perfection, nevertheless if the method is engineered by the combined efforts of all who are to be connected with it in advance of beginning production, and if it is thought through in detail at the start, it is certain that better methods and fewer changes will result. At the present time, much independent work is being done to develop better procedures for engineering methods in advance of beginning production. These procedures hold great promise of helping to facilitate methods-improvement work in the future.

MANAGEMENT, LABOR, AND GOVERNMENT MUST CONTRIBUTE

The methods engineer cannot by himself be expected to overcome the obstacles which prevent methods-improvement work from going ahead to the full limit of its potentialities. In fact, as was pointed out before, the methods engineer is merely a personification of a philosophy of production. To increase the effectiveness of methods-improvement work, management, labor, and government must contribute to the aggressive application of methods-improvement principles.

Specifically, because management is looked to to furnish leadership toward industrial progress, it would appear that management must do a better job of getting across to the public, and especially to that section of the public known as labor, the vital importance of methods improvements to the strength and prosperity of the country.

Management and labor together should co-operate to the fullest extent in methods-improvement work and should to-

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Attitudes Toward

METHODS IMPROVEMENT

By CLINTON S. GOLDEN

ASSISTANT TO PRESIDENT, UNITED STEELWORKERS OF AMERICA (ON LEAVE), VICE-CHAIRMAN, WAR PRODUCTION BOARD AND WAR MANPOWER COMMISSION

THIS is a paper about people—a paper about the release and use of human energy.

It is a report based on experience, and yet a report without mathematical equations or formulas. I cannot give you the precise measurements of a laboratory-conducted experiment because the observations come from the actualities of industrial operations and not the laboratory. Neither—and perhaps fortunately for you—can I discuss the subject of attitudes in the language of the professional psychologist. But I do want to try to tell you what labor feels about methods improvements and why labor feels that way.

In the real world of industry, one must distinguish between the logical and the actual, between what one knows and what one does.

Labor knows that technological advances and improvements in productive efficiency are desirable. Labor knows that only through such advances can more goods be created, work be made less wearing, and more time made available in which to enjoy the goods. The worker knows that increased productivity is fundamental to a rising standard of living.

But labor also knows that the end does not justify *every* and *any* means to attain it. The worker, through experience, knows and feels that improvements brought about in certain ways hurt him, and the *end* does not *always justify* the *means*.

It seems to me that there are two sets of controlling attitudes in all of us. One is a positive set: There is the human desire to belong, to be counted-in, and to be a part of the scheme-of-things; there is the desire to participate, to feel that one is helping to do a useful job; there is the desire to be recognized, to be treated equitably for what service one does.

The negative set of attitudes is equally powerful and controlling. There is the fear of being excluded, of being pushed out and counted out; there is the fear of being treated as an inferior, of not being told what is happening and what is needed; there is the fear of injustice, of the claiming of credit by others for what was rightfully yours.

If labor has often had a negative attitude toward methods improvement, it is because these fears have been realized.

These positive and negative attitudes exert themselves most forcefully at two different periods of time during a program of methods improvements; first, during the developmental period, the period of research and early application; and second, during the period when the results have become apparent. Because labor's attitude is so influenced by the second period, by the *results*, I wish to speak about it first. After all, it is the *results* which condition future attitudes.

In the space of a few years the nation has swung from a condition of far more workers available than jobs to a condition of more jobs open than workers available. This swing has affected the views of workers toward methods improvements.

During the 1930's, technological advances were being made and at the same time unemployment was severe and widespread. Labor then feared improved methods. In a society where technological advances continue without the economy growing at the same rate, the result is a constantly increasing surplus of workers and consequent unemployment. Under the fear of unemployment, the instinct of self- and group preservation transcends all other considerations.

The workers' *measure* of *increasing efficiency* of production is the *decline* in the manpower requirement. If improvements in methods of planning, organizing, and directing production *reduce* employment opportunities, the fear of workers for their own security will express itself in active, aggressive opposition, or in more passive measures of restriction which tend to counteract the efficiency of the new methods. Labor will not willingly and knowingly work itself out of a job.

Now labor knows that it is wrong and demoralizing to work halfheartedly, to have two men where one is adequate, to create rules and restrictions which hinder and hamper production. But when other jobs are not available, when management introduces new improvements without consideration of timing them to minimize labor dislocations, and without giving guidance to the displaced, then fear can and does override reason.

Labor also knows what action management takes with the financial results of improved efficiency. Improved methods usually mean lowered costs of production. There is a financial gain—profits to be utilized for *some* purpose.

Where management uses such profits to invest in new plant expansion, labor understands that efficiency in production is creating more production and more jobs. When management reduces prices to enlarge markets, labor understands that, too, means the translating of improved productivity into greater production. And where parts of the financial benefits are returned to labor as wage increases, labor appreciates that management is indirectly expanding production and jobs by increasing consuming power. But, when management keeps financial gains as idle reserves, when management writes off old investments without adding new capital, when management pays ***all*** the benefits to stockholders, labor questions the real economic efficiency of management. Workers resent selfishness, and sometimes respond by being selfish in their wage demands.

When the results of improved methods have been fear and unemployment, suspicion and selfishness, then no foundation of good faith is laid for labor's co-operation in increasing productivity.

The war has brought significant experiences, and in many cases, altered attitudes. The staggering industrial achievements of the war will be explained in a thousand different ways, particularly during this campaign year of 1944. I believe, however, that one fundamental reason for the welling-up of productive ideas and the multiple increase of efficiency is the assurance of useful jobs. The positive attitudes of intelligence and participation have come to the fore as fear of unemployment has declined.

We hear much of the efforts of scientists to smash the atom and to liberate the energies locked therein. Now there are millions of workers, many of whom in the total scheme of things seem no larger than an atom. And yet, in many plants

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and many industries, human energies have been released. The demands of war have brought forth initiative, invention, and self-reliance which were locked up within people, latent and unused, all through the depression. The war has clearly demonstrated that the liberation of these energies to increase production is directly related to the workers' feeling of confidence in their ability to find and to hold jobs.

During the depression when our economy was not continuing to grow, men tended to forget the old old fact that God and nature have no particular plan by which brain-power is distributed throughout the population. The traditional American belief in public education is founded on the recognition that ability is widely distributed throughout all the people. But for this ability to come forward *there must be opportunity*. With opportunity lacking during the depression years, the creative abilities of many thousands of people were held dormant.

It was no mystery to labor, however, that the men who live with the machines should have ideas as to how to obtain better results from the machines. Given the opportunity and the removal of the fear of unemployment, the fear that the worker had of the machine as a potential destroyer of his job was replaced by confidence that the worker could contribute to the development of the production processes. Labor will never be satisfied with an industrial society in which labor is fearful of the machine. One aspect of a free society to labor is the opportunity for *creative expression* through participation in the improvement of methods.

Once the fears of insecurity have been removed, the next step is the development of an orderly understanding of the distribution of the financial results which flow out of the improvements in efficiency. It is important that there be some recognition of the individual who is the source of the suggested improvement. It is likewise important that the benefits as translated into monetary terms be shared.

The most fruitful war experience proves again and again that such recognition and such sharing of benefits should not be on a selfish basis. Individualism can be of two types. There is the individualism that is aggressively competitive, that leads to vanity and the seeking of power, rather than the rendering of service. There is also the individualism that is co-operative that gives the healthy recognition of leadership through merit.

Workers, as human beings, appreciate the latter form. They know that large cash awards to *one individual* as a form of grand prize is not conducive to continuing effort on the part of the *entire* labor force. They also know that such rewards are often no real reflection of the financial gains resulting to the company from the improved processes. They further know that when management tries to make a hero or a prima donna of some one worker, then management is reflecting its attitude of superiority. Labor not only resents the motive of management in such cases, but also becomes incensed at the worker who falls for this personalized build-up.

An industrial enterprise is essentially a co-operative enterprise and the individualism to be developed and the recognition of improvements of method must be the individualism consistent with co-operative understanding. A first step is the establishment of a labor-management committee in which employees through their own organizations and quite independently of management select members to represent them in a consultative capacity with members of management, and in an atmosphere of no fear. The purpose of such committees is not to have one side dominate the other, or to have labor take over the management. The aim is free interchange of ideas between individuals equally interested in the advancement of production and the health of the enterprise.

Experience has shown that such committees greatly facilitate the acceptance by management of suggestions for improvements arising from workers and the acceptance by labor of the successes and failures of their suggestions. Oftentimes suggestions are advanced in ardent good faith, which just do not work. Management is sometimes afraid that to tell the worker his proposal is not a practical one will react unfavorably on morale. Through the labor-management committees, it is not management which informs the workers but the labor members. It is interesting to observe the extent to which workers will go to convince their own people that the proposal is impractical. They are willing to do this because they have been given the opportunity to observe and to convince themselves. The result is a growing capacity for self-government and co-operative discipline.

There are also cases where improvements suggested by workers actually reduce employment and create for some people an involuntary change of jobs. In such cases it is important that part of the financial gain of the improvement be set aside as a fund for the payment of retraining. With planning, it is often possible to co-ordinate those who would be dismissed with the normal quitting rate, so that new opportunities for continued employment in the same company can be found.

Experience has also shown that it is better for management and for labor to share the benefits of new improvements through modest individual awards. The principal part of labor's share should go into a common fund for all, so as to be reflected in general wage rates, or shorter hours, or longer vacations with pay. Such a policy builds up confidence of labor in the justice of management.

I have spoken of the changes in the attitude of labor toward technological advances during the war period. The growth of job security has tended to substitute intelligence for fear. Whether this same attitude of intelligence and participation will endure into the postwar world depends on whether the postwar world is one of job opportunity, or of job insecurity.

We know that the stimulus to increased productivity which the war has brought will not end with the war. We know that new methods devised for war production will be converted to peacetime production. We also know a very startling fact, well brought out by William L. Batt, chairman of the National Planning Association, in his testimony before the House of Representatives Special Committee on Postwar Economic Policy. Mr. Batt said, "We cannot get away from one striking aspect of this wartime picture, namely, that the war is consuming something over half of the national income, which means that half the national effort of this country is being used to produce goods that are being shot away, while the half which is left is producing at least as much, if not more, goods in dollar value than we ever had before in our history."

This is an amazing accomplishment. It promises either a future of great fears or a future volume of production twice what we knew in 1939.

During the war we will have increased the number of skilled and semiskilled workers by training in the war industries and in the armed services. Perhaps as many as 15 million persons will have received some such training, and after the war the available labor force for peacetime production will be between 55 to 60 million persons. Of these, 15 to 20 million, including demobilized soldiers, will be looking for or changing jobs. During the war we have also greatly enlarged our industrial capacity and our agricultural output. After eliminating investments for strictly war purposes, we may have increased our industrial capacity by 20 per cent. Our food production during World War II has already increased twice as much as it did during World War I. Despite these gains, I do not believe the world is overbuilt. I believe there is need for new capital, for new efficiencies in production, for the continued economic development of new regions of the country—including the South and the West. I know that the past is not good enough. Our task is not to reconvert back, but to convert *up*.

Whether we succeed in making this conversion depends in large measure on the attitude with which we approach the task.

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METHODS IMPROVEMENT

From the Viewpoint of Management

By J. K. LOUDEN

PRODUCTION MANAGER, GLASS AND CLOSURE DIVISION, ARMSTRONG CORK COMPANY, LANCASTER, PA. MEMBER A.S.M.E.

OUR country has demonstrated to the world beyond a shadow of a doubt that we have both a capacity and a genius for production unequaled by any other nation. We have in spite of the many problems of conversion for war, such as manpower dislocation, material shortages, and the like, increased the productive capacity of this country to a point where the value of our production has reached the astounding total of about $150,000,000,000 per year. Even taking into consideration the inflated value of munitions production as compared with peacetime products, this represents a tremendous increase over the 80 to 90 billion dollar production goals we were discussing just a few years ago. When we further realize that we have achieved these records at the same time we were forced to yield 11,000,000 of our finest men and women to the armed services, we begin to comprehend the tremendous potential of our postwar production capacity.

We must find ways and means to direct and divert this productive ability and capacity into channels of peace so that at the conclusion of the war we can maintain an economy that will absorb our returning service men and women and at the same time not cause undue or harmful dislocations within our present working groups. This can only be done by raising the standard of living not only in this country but in all others and thus create both new and greater markets for our goods.

Management as a whole realizes and is willing to bear its full share of responsibility toward this common industrial goal of providing more goods for more people at lower prices. Translating this thought further, management then desires for its individual establishment to achieve the goal of high wages, high quality, low costs, and low prices. The goal of the individual plant manager then is to have a high-wage, high-quality, low-cost plant.

HARD-HITTING PRODUCTION TEAM ESSENTIAL

The only way to achieve these goals is through attaining and maintaining maximum effectiveness in all our productive efforts. To do this we must not only have a good product and proper facilities and equipment, but above all we must have a hard-hitting production team composed of management, workers, and technicians in our plants and laboratories.

Our country will undoubtedly have to bear the major production burden required to rehabilitate devastated areas after the war as well as to reconvert our own and other countries' factories to peacetime operations during that same period. American industry can and will meet that challenge as successfully as it has that of producing for war.

Then, following that period of transition and rebuilding, our production system will meet the greater test of competition for our own as well as foreign markets, not only from within our own borders but from other countries which will by then be regaining their production strides.

We must remember that these countries too have made rapid gains in the "know how" of production, in spite of their added difficulties of being either closer to the war zones or actually in them, so they will be worthy competitors. Another important consideration is that in Russia we have a new industrial giant which will in future years become a major factor in world trade.

We know that the marginal producer has always suffered a high rate of industrial mortality. That is as it should be, because in the spirit of free competition that has made our country great, there is no room for the inefficient or incompetent producer. In the postwar world, because of our own higher rate of productivity plus foreign competition, I am certain that we will also find many of those firms which have inhabited that shadow land between the effective and the marginal producer fading from our industrial scene unless they face the competitive facts with realism and action.

The question of postwar inflation or deflation, and what to do about it, comes to mind in discussing this problem of productivity. Which we will have, if either, is beyond my powers of prediction, but I am certain of one thing, that is, the efficient production organization has a much better chance to survive any type of economic upheaval than has the inefficient one.

Unfortunately, for whatever the reasons might be, our national economy in the past has not been kept in balance. We have not found a sound economic pattern whereby we can achieve our goal of more goods for more people at lower prices and keep our country on an even economic keel. Our genius for production has outstripped our ability to cope with our financial, distribution, and social problems, resulting from or related to our ability to produce. To reach our full measure of success we, in industry, must devote more brainpower and energy toward solving these vital problems and bringing them into line with our productive ability and at the same time not diminish or restrict in any way our ability to produce.

The strength of our country has always rested in that ability, and I believe no one will deny that the theory of scarcity and the theory of plowing under our productive capacity have been thoroughly discredited as solutions for our economic ills. Therefore while organizing to solve these related problems we must approach our future with full determination to carry forward with increasing vigor our never ending campaign of increasing our individual and collective productivities. Accordingly we must embrace a program of cost reduction through waste elimination that calls upon the united energies of our management, labor, and technician team.

PERPETUAL METHODS-IMPROVEMENT PROGRAM

Not forgetting that we have no more than indicated the national problems that must be solved if we are going to keep our economy in balance, let us now turn to a more detailed discussion of the problems such as a perpetual methods-improvement program brings to a plant or company.

First of all we must face the fundamental fact that if we are going to survive as an industrial unit we must constantly increase our productivity and lower our costs. If we are successful in doing so it is reasonable to expect that through lowered selling prices we will find expanding markets for our goods and therefore greater opportunities for our people, while maintaining a sound profitable business enterprise with adequate reserves to meet changing conditions. Our greatest problem in attaining these goals is meeting and overcoming the series

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of dislocations these changes often bring to an organization.

No one will deny that from a long-range viewpoint technological change has proved highly beneficial to our country and its people. We can cite statistics by the yard and mention industry after industry to prove that over a period of time through improved methods and equipment our industrial economy has grown great, with rising wages, increasing total employment, and lower selling prices being the result. Therefore we do not have to justify technological change from a long-range viewpoint. Our major problem rests in the series of short-term restricted dislocations that affect individuals and relatively small groups of individuals at the time technological changes are introduced into a plant or industry. There may be occasions when large groups are temporarily affected by labor-saving devices in an industry or occupation, but for our purposes we can consider the problem from a plant viewpoint.

Accordingly the company which will be most successful in reaching its goals of high productivity and low costs will be the one that is most successful in preventing harm from falling upon an individual or group of individuals as a result of such a methods-improvement program. If in the full analysis of its particular situation it is able to so organize its program and fortify it with policies that permit and encourage co-operation and teamwork of a high degree between the three groups involved, then they will find themselves limited only by their individual and collective abilities to cope with their situation and the outside influence that may arise from our efforts to solve our problem of national economic balance.

Internally, we find the greatest obstacles to such a program springing from the "resistance to change" attitude, which is not confined to any particular level or levels in the organization, and the fear of personal economic harm usually felt most strongly by the hourly workers. Resistance to change usually stems from pride of authorship, fear of reflection on ability, and, many times, mental inertia. Fear of economic harm, on the other hand, usually takes the pattern that a job will be de-emphasized to the degree that a man's skill and knowledge will no longer be an economic asset to him, that a new method will involve skills he cannot learn, or there will be a reduction in the force that will throw him out of work.

Therefore the first step is for management to get its own thinking straightened out and develop a program and group of policies that will be clear, concise, and designed not only to do a sound technical job but also to provide maximum protection for all those involved and to encourage their maximum co-operation and interest. Management must recognize the importance of careful work planning. It must recognize the importance of setting a pattern for the remainder of the organization by intelligent preplanning of moves to be made and to build in its people that confidence that comes from working where changes made and plans laid give strong evidence of sound sure thinking.

In addition, we must recognize the full responsibility each level of management must accept for such a program, the quality of engineer or technician required, and his proper place in the organization. Each member of every level of management must be made a part of the over-all program to the degree that he can and will accept full responsibility for the program as it is developed and as it will affect him and his people. The engineers and technicians must be of the highest caliber obtainable and the importance of their work recognized in the organizational plan by providing for proper compensation and appropriate position at the various levels of the organization.

SUBJECTS TO BE COVERED

When management has its policies and thinking concerning this program well in hand it must then be prepared to express and discuss them with the hourly employees and all levels of management in order to bring them into definite practical form and thus insure understanding and acceptance. Examples of subjects that should be covered by such policies, together with possible statements under them, are as follows:

1 *The General Objective of the Study.* To so simplify and organize the work that waste will be eliminated to the degree that costs are lowered, the product improved, and the company's competitive position improved to the general good of all.

To protect the jobs and earnings of all employees concerned to the maximum degree possible. To keep all employees fully informed at all times and to make them partners in the program to the maximum degree practical.

2 *Job Security.* No one will be laid off as the direct or indirect result of this program. Should anyone be released from his duties by the study he will be given plant-wide seniority and every effort made to re-establish him at his highest skills. Any excess labor remaining will be placed in a pool until such time as normal labor turnover or expanding labor requirements reabsorb them into regular jobs.

3 *De-emphasis and Dislocation of Skills.* De-emphasis of skills does not necessarily follow such methods-improvement programs. Just as frequently a greater concentration of skill use results from proper organization of the work. Should the skill requirements on a particular job be lessened to a degree where the economic value of the job is materially lessened, then every effort will be made to transfer the worker to other equal skill jobs or to find other means of maintaining his take-home pay.

Where through change in job content skills are disrupted, formal programs to train the workers in the new methods will be established. Ample time will be allowed for this purpose and earnings will be fully protected during the training period. Strong efforts will be made to keep assignments in line with each worker's capabilities and interests. Other policies will be needed to cover a given situation but these are representative of the type of thinking and planning that must be a definite part of any normal methods-improvement program.

EMPLOYER-EMPLOYEE RELATIONSHIP

If in the past there has been any single reason for the failure to achieve full results from such a program, other than the failure to recognize the quality of individual required to serve as the technician and the failure to provide economic protection to the employees, it has been the failure to provide the proper place in the development of the program for the first lines of supervision and the operators themselves. If we as managers fail in this respect, we are overlooking a source of ideas and job knowledge that can well provide the next great forward impetus on the path of our industrial progress.

However, before we can expect our supervision to properly play their role in this program and become the driving force back of their department's part in it, we must see to it that they are not only given the opportunity to become familiar with the tools and work methods of the technicians but also that the relationships between themselves and these technicians be clearly and definitely established. It is through this knowledge and understanding of each other's problems, and the knowledge and understanding of the approaches to the solution of their common problems, that the basis for sound teamwork between these two groups is laid.

The supervision is thus enabled not only to participate to the proper degree in these solutions but also through his knowledge and position in the program can reflect it properly to his people. They naturally look toward their foreman for guidance and have confidence in him. With the knowledge that he is guiding the development and execution of this program in their department, they know that he is in a position to protect their interests fully as laid down by the general policies governing this work.

As just indicated, it is not enough to provide the hourly employees with economic protection if we are going to achieve

(*Continued on page 479*)

NAZI CONTROL OF GERMAN BUSINESS[1]

By D. S. TUCKER

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IT IS an axiom of statesmanship which the successful founders of tyranny have understood and acted upon that—"great changes can best be brought about under old forms." This quotation from Henry George forms both the preface and the conclusion to the recent study of German business[2] published by The Brookings Institution. Four things may be said to have conditioned the development of Nazi control over German business: the Nazi party's observance of established forms, the Nazi totalitarian philosophy, the pressure of war, and the gradual step-by-step process through which the control over business has been transferred from stockholders to politicians. Of these four the most remarkable is the first. German business still presents the outward appearance of being managed by its owners.

A government might take over the management of private business by any one of four methods: confiscation, purchase, lease or regulation, provided regulation could be made sufficiently detailed. Hitler became chancellor on Jan. 30, 1933, and the extension of government power over business began only a few months later. The choice of method was in this instance relatively easy. Confiscation of property would have dried up at once the foreign loans on which German rearmament and the Nazi program then largely depended. Purchase or lease of corporate property would have involved the state in fixed charges too great to be considered. Regulation avoided these difficulties and possessed two additional advantages: It retained the technical skill of existing managers, and even under very detailed regulation the existing forms could be preserved.

The great achievement of the Nazi party has been the domination of managerial decisions under the guise of regulation. The contribution of the recent Brookings study is revelation of the extent of this domination.

The Nazi state has added one enterprise frankly controlled by the state, the Hermann Goering works; but this has been the exception. The Reich's holdings in the German Shipbuilding and Engineering Company were sold in March, 1936. The control of German United Steel was sold almost simultaneously. During ensuing months the Reich sold its interests in the Hamburg South American Shipping Company, the Hamburg-American Line, the North German Lloyd and the Kontropa Corporation, all of which had been acquired by previous administrations. Nazi control, in general, has been effected through regulation alone.

CONTROL OF ENTRY AND TERMINATION

In certain industries restrictions on the starting of a new enterprise antedated Nazi control. In Germany, as in the United States, a "certificate of convenience and necessity" had long been necessary for starting a new public-utility company; but the first wide extension of restrictions on new business came in 1932 when Bruening prohibited new five-and-ten-cent stores. In May, 1933, the Hitler government prohibited the opening of new retail stores of any kind without special permission. The purpose of this act was apparently political—to win the favor of existing shopkeepers. The establishment of new mail-order houses was similarly prohibited. Jews, if already established in a business handling "cultural products," were driven out by a new requirement for membership in the Chamber of Culture. The policy of requiring a license to operate was extended to advertising firms (September, 1933), to credit institutions (December, 1934), to textile manufacturing (December, 1935), to the purchase of agricultural real estate (January, 1937), and to repair work (1943). The promotion of new manufacturing plants has been limited chiefly by methods other than licensing.

Restriction in some lines has been supplemented by compulsion of entry in others. In some instances only contributions of capital were demanded; but in other instances operation also was required. Thus in October, 1934, the Nazi government required "a selected list of producers of lignite to provide funds for, to build, and to operate plants producing gasoline and lubricants from that mineral." Paper manufacturers were required similarly to undertake the production of cellulose; the processors of vegetable oils were required to build a whaling fleet; tobacco dealers and cigar manufacturers were required to form a corporation to grow tobacco in Europe.

Closing down of going enterprises has been enforced for a variety of reasons: to injure Jews; to weed out surplus middlemen; to curtail the production of civilian goods; to concentrate production in the best-equipped plants; and to conserve manpower, fuel, or other resources. In some instances whole enterprises have been closed. Wholesale dealers in butter have been reduced from 5000 to 1500, and distilleries from 12,000 to 755. In other instances a reduction of the number of branches is all that has been required. About one third of the branch offices of the big banks have been thus "canceled."

Enforced continuance of operation is a matter of special statute in some instances (small farms, power plants, and mining enterprises); but in most instances it results from the wording of the conscription act of June, 1938. A businessman who attempted to close his plant would presumably be drafted and put back on his former job. In Nazi philosophy, the individual (and his property) exist for the service of the state.

CONTROL OF OUTPUT

The scale of operations of a going enterprise is of course controlled in some instances by government purchases; but three restrictive controls are also found. These are the government's control of capital funds, of raw materials, and of the labor supply. All three of these controls in Germany antedate the war emergency. Though announcement of the fact was long delayed, it was actually less than five months after Hitler's rise to power that a committee headed by the president of the Reichsbank was given charge of the allocation of capital funds. This committee has lifted its embargo on private issues only for approved firms in selected industries.

The control of materials developed more slowly. The importation of butter and certain other farm products was restricted early in 1933. All imports were subjected to control in 1934. In this year also domestic raw materials began to be controlled. By 1936 there were five Commodity Control Boards. By 1939, when the war began, there were already 31 boards which collectively controlled every raw material for which there were statistical records.

The labor supply was organized by an act of November, 1935. This decree gave to the national Employment Service Board a

[1] One of a series of reviews of current economic literature affecting engineering, prepared by members of the department of economics and social science, Massachusetts Institute of Technology, at the request of the Management Division of The American Society of Mechanical Engineers. Opinions expressed are those of the reviewer.

[2] "How Nazi Germany Has Controlled Business," by L. Hamburger, The Brookings Institution, Washington, D. C., 1943.

monopoly control over employment service, vocational guidance, and the placing of apprentices. Since 1934 farm laborers have been prohibited from voluntarily seeking better opportunities for employment. This prohibition of voluntary movement was extended gradually to other trades. Every German has been required also to carry an Employment Book, a copy of which is held by the national Employment Service Board. The availability of this information has facilitated the enforcement of compulsory mobility. During the winter of 1938–1939, for example, all former miners, if engaged in occupations other than agriculture, were ordered to return to the pits. Individual workers also are transferred as needed. Women and the men not gainfully employed have been conscripted. The national board may transfer individual workers at any time. It may thus determine the number who are available to any specific employer.

CONTROL OF PRICES

Nazi control of prices began (1934) with the setting of minimum wage rates. These minima were made also maximum rates in 1938. Wage income depends, however, on the amount of overtime as well as the wage rate. Devices to control the spending of additional wage income culminated in the Iron Savings scheme under which employers deduct the amounts indicated by workers and these savings are then "blocked" for the duration. Savers may use these savings only by securing special permission from the authorities.

Minimum prices were set by the state for certain farm products in 1933. For manufactured products the cartels were encouraged to set minimum prices. Many of the earlier acts of the Nazi party did indeed favor businessmen at the expense of the rest of the community; but in November, 1936, a government decree introduced general price control and converted existing prices into maxima as well as minima. Management of the cartels has also been taken over by government-appointed "leaders." That the Nazis selected "leaders" normally from the existing membership did not alter the autocratic character of the new arrangement. Almost the only objects left free from price control were philatelic collections, Persian rugs, oil paintings, and riding horses. Even interest rates and stock prices are now prescribed.

Though individuals may not deviate from government prices, government authorities may alter the prices prescribed. Technical improvements, the absorption of rising costs out of profit margins, and the compulsory reduction of many prices have permitted the general price level to remain relatively stable. In 1936 the wholesale price index stood at 104.1. By June, 1943, it had risen only to 116.1. Many goods of course are now unavailable, and others have deteriorated in quality; but within Germany, black-market operations have been apparently more conspicuous than important. Price control has apparently been effective.

CONTROL OF PROFITS

Accounting methods have been standardized in order to perfect the control over prices and profits. Companies in every industry must now use the official classification of expenses which applies to all business. Taxes are not an expense but a distribution of profits. Controls over profits, as thus defined, are of two kinds: control over magnitude and control over use. It is more convenient to examine first the purposes for which profits may be used.

Profits are available first for taxation. A graduated corporate income tax absorbs 30 per cent of all profits and 55 per cent of corporate profits in excess of 500,000 marks. Cash dividends, the second use, are rigidly limited. A few corporations which had previously paid higher rates are now allowed to pay 8 per cent. All other corporations are limited to 6 per cent on the par value of their stock. Net additions to surplus may be used for three purposes. Some corporations are both permitted and required to enlarge their own facilities. Other corporations are permitted or required (the two words are apparently almost synonymous) to invest in designated new enterprises which the government desires to have promoted. All other corporations buy government bonds.

The magnitude of the profits available for these uses is controlled chiefly by two devices: price control and "contributions." For industries as a whole, prices are set so that a well-managed enterprise may make "adequate" profits on "necessary" (not actual) capital. For individual firms there are also "contributions." Mr. Priester has estimated that these contributions have ranged from 2 to 6 per cent of total turnover; but the precise amount collected thus cannot be stated because these contributions are not paid into the imperial treasury. In some instances corporations are required to support competitors whose plants have been closed. In other instances fortunate enterprises are required to subsidize the production of goods whose prices the government desires to reduce. Processors of wheat flour and others are, for example, thus required to subsidize the mills producing rye flour. The control of profits is interlocked with the control of commodity prices.

ADMINISTRATION OF CONTROL

The instruments of government control are of two kinds: government bureaus and the previously independent business associations, such as trade associations and chambers of commerce and industry. The functions of the previously voluntary organizations are to explain the new rules to members, to assist in enforcement, and to build up sentiment in favor of complete obedience. Businessmen have been required to join. The structure of these organizations has been streamlined and divided into Gaus or districts. The Minister of Economy appoints the "leaders" of the major organizations, and these leaders in turn appoint the leaders of smaller units. The Nazi party which started by protecting the businessman at the expense of the rest of the community, has ended by controlling even the channels through which businessmen formerly expressed their wishes.

The government agencies which control business are not systematized as in Russia. Control is divided among many bureaus, though all of these bureaus were in 1936 made subject to Goering who was then given legislative and dictatorial power over German economy. This high command, in addition to a chief, has also a general staff and a bureau. Very little information seems, however, to be available with respect to these two subordinate co-ordinating bodies.

Regulation, when it becomes so detailed that it controls every important managerial decision, cannot be a matter of general rules alone. Exceptions must be made to meet special conditions. This has apparently created the need—or opportunity—for the public-relations executive, the contact man, "fixing," and "graft." More serious for Germany, and more pleasant for its enemies, is the fact that the plethora of changing, and often conflicting, regulations issued by the different bureaus may have impaired German business efficiency. The Germans are still very thorough, and they are still highly efficient in technical matters. It is not certain, however, that German business administration is as efficient as it was during predepression years.

Policies must be contrasted always with methods of administration. If policies, rather than methods, now form the topic of examination, and if these policies are judged solely by their usefulness in the prosecution of war, then a kind of deadly efficiency may be seen in the present German government. If judged by military efficiency alone, then the Nazis since 1936 have made very few mistakes in economic policy. The Nazi economy has been converted to war purposes more completely as well as more promptly than our own.

Performance of WATTS BAR STEAM STATION *of* TVA

By M. K. BRYAN and R. T. MATHEWS

CHAS. T. MAIN, INC., BOSTON, MASS.

INTRODUCTION

THEODORE B. PARKER[1]

THE Act of Congress creating the Tennessee Valley Authority, in addition to other major requirements, charged the Authority with providing for the national defense. In order to insure an adequate power supply for the production of war materials, general studies were started in 1939, with regard to the place of steam-generating capacity in the TVA system.

By the spring of 1940, these studies had progressed to the point that, when the National Defense Council requested information regarding the possibility of furnishing additional power in the Tennessee Valley area, the feasibility and value of additional steam generation had been established. In accordance with recommendations of the Advisory Commission to the Council of National Defense, this project was authorized by Congress on July 31, 1940, as an emergency national defense project, for completion early in 1942. The authorization was for steam-electric generating facilities with rated capacities of 120,000 kw. Later, on April 5, 1941, authorization was given to add 60,000 kw to the station.

Further studies, based on consideration of load, transmission facilities, and coal supply, led to the conclusion that the steam-generating project should be located in the eastern area of Tennessee. A comparison of various sites determined the superiority of a single steam plant located in the vicinity of Watts Bar Dam. The advantage of this site included the elimination of long transmission lines, railroad connections, the availability of adequate water for condensing, and the use of the construction facilities already available in connection with the simultaneous construction of Watts Bar Dam.

The author's company served as consultants in the selection of the site and major steam-plant equipment. With this firm acting as consultants, the work was carried out by the Authority's Engineering and Construction Departments. The efficient co-operation of all parties and departments developed an organization for designing and constructing the Watts Bar Steam Plant; producing a fundamentally sound generating station now operating satisfactorily, economically, and essentially as predicted. What is more important, this major undertaking, though free from innovations and purposely designed and built with major equipment of proved stock designs, was completed in accordance with the accelerated construction schedule and at a cost below the original estimate. The first 60,000-kw unit began commercial operation in 18 months and was followed by the second unit about 6 weeks later.

It should be pointed out that the design and construction of this project were carried out under considerable pressure at a time when shortages of materials and equipment-manufacturing facilities were developing. The premises of design, plant location, and general description of the plant were treated in a previous paper.[2]

Through the co-operation and ability of Messrs. W. F. Uhl, M. K. Bryan, and T. R. Mathews, consulting engineers of Chas. T. Main, Inc.; G. R. Rich, TVA's Chief Design Engineer; A. L. Pauls, TVA's Chief Construction Engineer; F. C. Schlemmer, TVA Construction Project Manager, and the many individual engineers of the TVA Engineering and Construction Departments, this major steam plant now contributes its full share to the war effort.

GENERAL PARTICULARS OF STEAM STATION

The Watts Bar Steam Station in May, 1943, had been in operation for more than 16 months and was satisfactorily performing its function in the TVA system of generating emergency power for war plants. Although this station was built as part of the national defense program and will operate at a high capacity factor for the duration of the war, the economic design and the selection of major equipment were primarily governed by the anticipated long-term-trend use of this steam-power capacity as part of a large, predominantly hydroelectric system. At the inception of the design, the contemplated use of this station as stand-by steam capacity indicated an average annual generation of approximately 4000 hours to firm up high-grade secondary hydro power.[2] Naturally, the present base-load operation of the plant, due to wartime demands for power, is not a true indication of the more permanent function of this steam plant in the TVA system.

Fig. 1 indicates the phenomenal growth of the TVA power

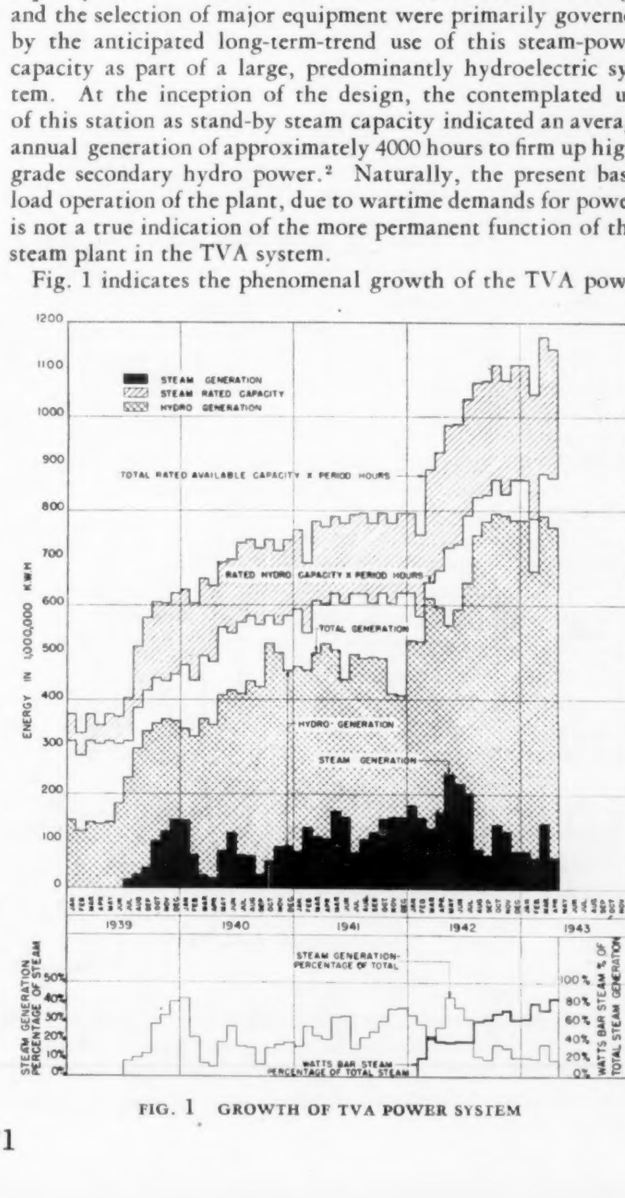

FIG. 1 GROWTH OF TVA POWER SYSTEM

[1] Deceased. Former Chief Engineer, Tennessee Valley Authority, Knoxville, Tenn.

[2] "The Watts Bar Steam Power Station of the TVA," by G. R. Rich and R. T. Mathews, MECHANICAL ENGINEERING, vol. 63, 1941, pp. 773–779.

Contributed by the Power Division and presented at the Spring Meeting, Birmingham, Ala., April 3–5, 1944, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

system since 1939. During this time, the total generating capacity more than tripled, and the actual generation increased over 5 times, thus making a most valuable contribution to the war effort.

The use of steam power is also illustrated by the graphs showing the relation of steam power to total system generation and capacity. It is to be remembered, with reference to the steam generation record in Fig. 1, that the years 1939, 1940, and 1941 represented a period of low rainfall, deficient stream flows, and decreased reservoir storage, while the years 1942 and 1943 to May, 1943, were favored with average, or better, rainfall. The predominance of Watts Bar in steam-power generation is to be expected, due to its superior economy compared with the older steam plants, and also because increased hydro capacity and improved stream flow have reduced the present demand for steam power.

The major equipment in the Watts Bar Steam Plant was selected for normal base-load operation during low stream flow and to permit an operating range to one-half load without boiler difficulties during periods of high stream flow when steam capacity may be required. The total system capability is sufficient during periods of high and also low stream flow so that forced outage of a 60,000-kw steam unit at Watts Bar would not decrease the ability of the system to meet the load demand, for hydro spinning reserve would take over the loss in steam generation.

Spinning reserve is obtained in the system by motoring, as synchronous condensers, hydro units not needed for energy at storage reservoir and run-of-river plants. Operating in this manner, these units require only a few second-feet of water for cooling and seal lubrication and will pick up full load in approximately 8 sec after power interruptions. The only effect on system operation of a forced outage of a steam unit would be the depletion of reservoir storage below scheduled operating levels. In view of these factors, the station was designed for unit operation of relatively large units with less spare equipment in auxiliaries than might be considered advisable in a predominantly steam system. This reduced the initial cost.

Steam-Plant Site. The steam-plant site is located on the west bank of the Tennessee River, approximately 3500 ft downstream from the Watts Bar dam and hydro plant. The area occupied by the plant, transformer yard, and adjacent buildings is approximately 9 acres, while the coal-storage yard covers approximately 11 acres. Additional land is used for railroad tracks serving both steam and hydro plants, for circulating-water intake and discharge tunnels, and for the disposal of slag and ashes.

Before the steam plant was authorized, 9 miles of access con-

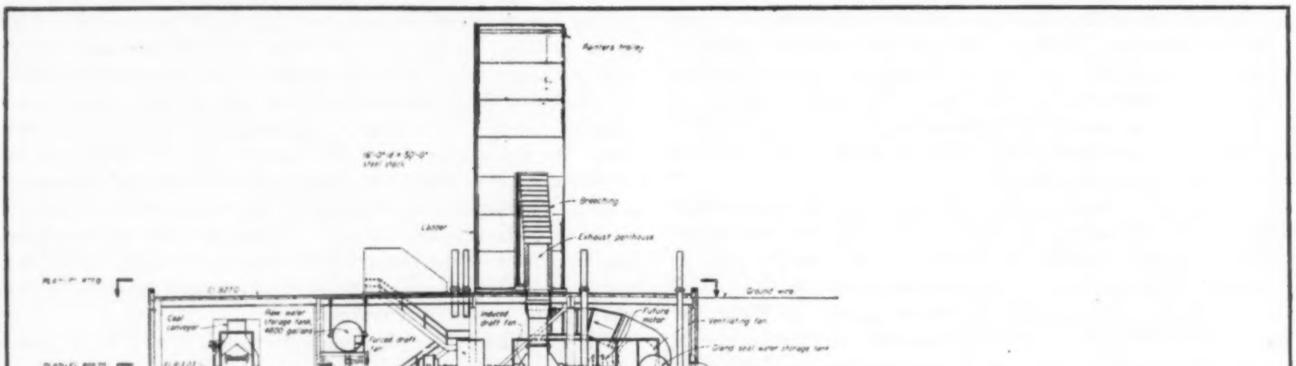

FIG. 2 PLANT CROSS SECTION

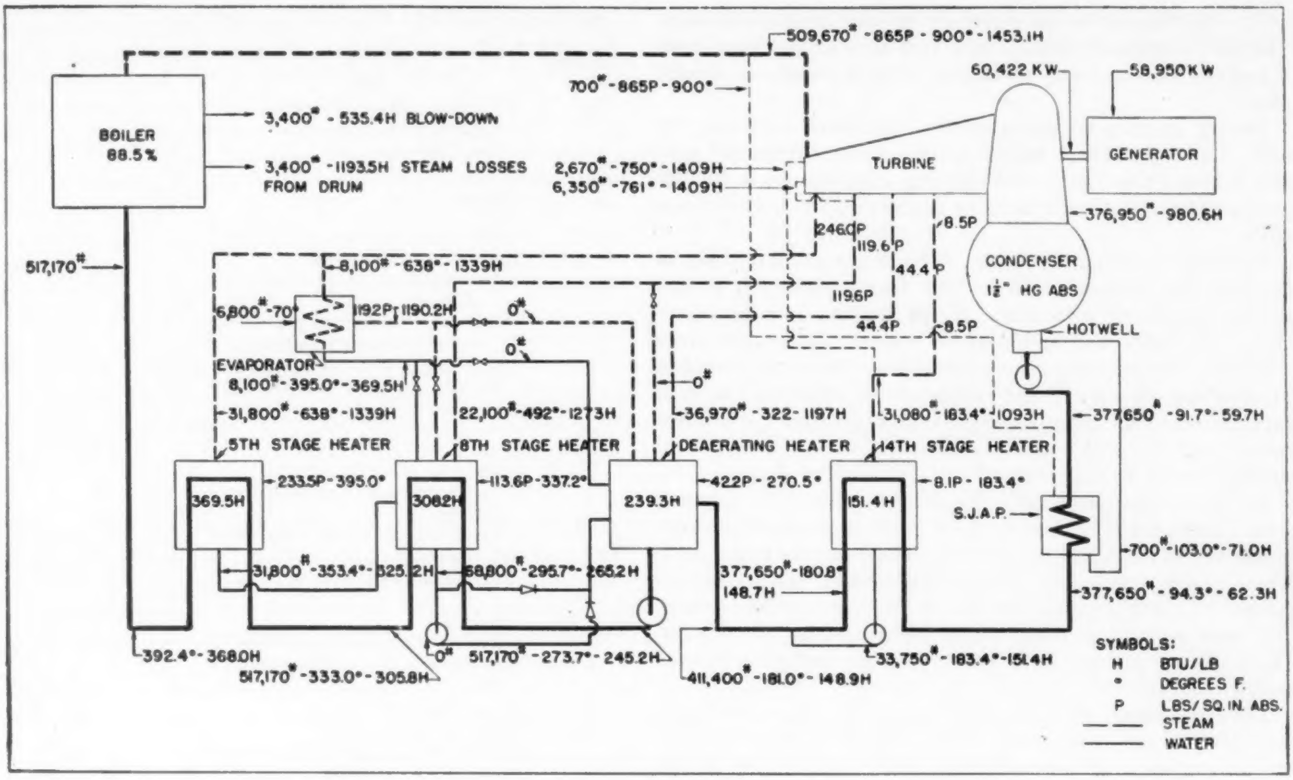

FIG. 3 HEAT-BALANCE DIAGRAM

struction railroad from the main line of the Cincinnati, New Orleans & Texas Pacific Railroad Company near Spring City, Tenn., were built to serve the Watts Bar dam project. This railroad is now used to deliver coal to the steam plant.

Electrical Equipment. The generator voltage, 14 kv, is stepped up to 154 kv by unit transformer banks through oil circuit breakers at the steam-plant switchyard. A transmission line 3500 ft long ties this switchyard with the main 154-kv switchyard at the hydro plant. At this point, each steam-plant generator can be connected to either of the two 154-kv buses which tie into the main transmission system.

Station service is supplied through a 7500-kva, 13,800–2300-v transformer connected through motor-operated disconnecting switches to the low-voltage side of each power transformer. Motors above 250-hp are supplied at 2300 v and smaller motors are supplied at 440 v from the 2300-v distribution through a 750-kva, 2300–440-v transformer per unit. Normally, each unit is operated independently without ties between the auxiliary power buses However, automatic switching equipment is provided which connects the 2300-v or the 440-v buses of adjacent units in the event voltage on any bus is lost. A separate source of power is obtained, when the plant is shut down, from a 600-kva transformer connected to a 12-kv rural line.

Condenser-Circulating-Water System. No circulating-water pumps are used at the steam plant, cooling water flowing by gravity from the Watts Bar reservoir through two 78-in-diam precast reinforced-concrete pressure pipes. A closed circulation system from the dam to a common condenser-discharge canal is obtained by maintaining the level in the canal by a weir discharging to the river.

Coal-Handling Equipment. The coal-handling equipment has been designed to receive coal either by rail or water and has a capacity of 400 tons per hr. The hopper building is provided with two tracks, one having a 70-ton capacity rotary car dumper, designed to unload a minimum of 10 cars per hr, and the other providing for bottom dumping of cars only. Waterborne coal is delivered to the hopper building by belt conveyer from the dock. All coal is crushed in the hopper building and then conveyed either to the boiler-plant bunkers or to a ground pile for distribution to storage. The coal-storage yard, covering approximately 11 acres, has a capacity of about 200,000 tons. Coal is distributed to and reclaimed from storage by means of a drag scraper. Each boiler has a bunker capacity of 1200 tons, about 40 hr at rated capacity.

Steam Generator and Accessories. A cross section of the arrangement of the major equipment of one 60,000-kw turbogenerator and steam-generator unit, with its auxiliaries, is shown in Fig. 2. The steam generator is designed for 600,000 lb of steam per hr, with steam conditions at the superheater outlet of 900 psi and 900 F. Four pulverizers and eight burners are provided for each boiler. Two duplex fan units are provided per boiler, each unit being driven from the forced-draft-fan end by a 720-rpm constant-speed 800-hp motor.

At the capacity of 600,000 lb of steam per hr, the unit is designed to have an efficiency of 88 per cent, with secondary air to the burners at 550 F, flue gas leaving the economizer at 665 F, and leaving the air heaters at 328 F.

Turbogenerators and Auxiliaries. The turbine is designed for 850 psi gage, 900 F, at the throttle, and a back pressure of 2 in. of mercury abs. It is an 1800-rpm unit of the single-cylinder impulse design, having seventeen stages, with four stages of extraction for feedwater heating. The generator is rated 60,000 kw, 0.9 power factor, 66,667 kva, 3-phase, 60-cycle, 13,800-v, and has a direct-connected exciter and a pilot exciter.

The condenser is designed to condense 400,000 lb of steam per hr with 85 per cent clean tubes, when 70,200 gpm of water is circulated at 76 F, with a resulting pressure of 1.8 in. of mercury abs. The condensers are of the single-pass divided waterbox type, containing 40,000 sq ft of surface in $^7/_8$-in-OD 18-Bwg copper-nickel tubes 26 ft long.

HEAT BALANCE

The heat-balance diagram for one unit is shown in Fig. 3. Emergency cross connections have been provided between the main steam and boiler feedwater system of the first two units and can be made between the third unit and the future fourth

unit. No ties exist between the first two and the last two units. The plant is operated entirely on a unit basis and to May, 1943, it had not been necessary to use any of these emergency connections.

During starting-up periods, it is necessary to pump the fifth- and eighth-stage heater drains as the differential pressure between the eighth- and eleventh-stage heaters is not sufficient to force the drains into the deaerator at its higher elevation.

Make-up is treated Tennessee River water preheated before entering the evaporator shell. The deaerating heater is used as the evaporator condenser, if the feedwater is by-passed around the fifth- and eighth-stage heaters. The same vapor connection between the evaporator and the deaerator is used to increase the capacity of the evaporator by reducing the shell pressure when the plant has been started up after a shutdown period, and distilled water is required to refill the 40,000-gal distilled-water storage tanks.

All plant auxiliaries are electrically driven. In general, spare equipment is limited to those auxiliaries essential to the protection of the major equipment. These include boiler feedwater pump, condensate pumps, and turbine lubricating-oil pumps. Each boiler has one motor-driven boiler feed pump. One spare motor-driven feed pump is provided for two boilers. The feedwater piping is arranged so that any pump can be used with either boiler.

The expected net plant heat rate for the data shown in Fig. 3 is 11,170 Btu per kwhr at a generator output of 58,950 kw and $1^1/_2$ in. hg abs. Performance tests made on one unit at approximately 1.5 in. hg abs condenser pressure gave the following results:

Generator output, kw	Test Results,[a] Btu per kwhr, net plant	Design Btu per kwhr, net plant
66700	11220	11340
58300	11090	11150
51200	11200	11140
39700	11270	11340

[a] Superheat temperature was approximately 10 deg F low on all tests.

Design calculations indicate that the best net plant heat rate will vary from 55,000 kw in the summer to 47,000 kw in the winter with improved vacuum.

INITIAL PLANT COSTS

A summary of the construction costs of the plant, based upon the actual costs of three units (180,000 kw) and commitments for the fourth unit, is shown in Table 1. The contingency item, about $560,000, had not been used at the time of assembling the figures. The costs of land, switchyard, and transmission line to the combined hydro and steam switchyard, approximately 3500 ft away, are not included in the costs given.

RECORD OF ENERGY PRODUCTION

A summary of the energy-production record of each generating unit from the time of its initial operation to the end of May, 1943, is given in Table 2. The maximum load on generators *A* and *B*, of 72,000 kw, occurred during the period of initial operation, when the units were being tested to determine their safe load limit. It was determined, with the approval of the manufacturer, that these units could safely carry 70,000 kw continuously. The maximum generator output for continuous operation has been 65,000 kw, because of steam-generator limitations and quality of coal burned. Experience with the steam plant indicates that the minimum load which can be carried by a unit will be 12,000 to 15,000 kw for short periods, and that it will be necessary with this loading to increase the load periodically to about 25,000 to 30,000 kw to deslag the primary furnace.

The lower station serviceability factor of Unit B is largely

TABLE 1 SUMMARY OF COSTS,[a] FOUR UNITS—240,000 KW

Account[b] No.	Item	Per cent of direct cost		Cost per kw
311	Structures and Improvements:			
	General preparation of site	0.37		
	Yard improvements	1.50		
	Substructure	3.73		
	Superstructure	11.80		
	Total		17.40	
312	Boiler Plant Equipment:			
	Steam-generating units and auxiliaries	21.23		
	Heaters, evaporators, pump, and water-treatment equipment	3.27		
	Coal- and ash-handling	6.26		
	Piping, instruments, and controls	9.22		
	Total		39.98	
314	Turbogenerating Equipment:			
	Turbogenerators and foundations	26.51		
	Condenser and circulating-water system	7.28		
	Piping and instruments	1.24		
	Total		35.03	
315	Accessory Electrical Equipment		6.31	
316	Miscellaneous Power-Plant Equipment		1.28	
	Total direct cost		100.00	$64.67
184	General Expense:			
	Administrative, design, field engineering, access road, and employee housing			
	Total		13.63	8.81
	Contingency		3.63	2.35
	Total			$75.83

Analysis of Building Volume

Steam plant only[c]			22 cu ft per kw
Turbine room			30.3 per cent
Boiler room: Bunker bay	16.6 per cent		
Boiler bay	35.2		
Pump and heater bay	13.1	64.9	
Service and office bay		4.8	
		100.0 per cent	

[a] Exclusive of switchyard and land.
[b] Federal Power Commission uniform system of accounting.
[c] Based upon ultimate installation of 240,000 kw.

TABLE 2 OPERATING RECORD OF UNITS A, B, AND C

	Unit A	Unit B	Unit C
Date of initial operation	Mar. 11, 1942	Jan. 25, 1942	Jan. 22, 1943
Net kwhr generated	425119900	480545800	55738200
Maximum kw load on generator	72000	72000	66000
Hours available for service	900	510	775
Hours generating	7907	8526	1266
Hours unavailable	1154	2012	297
Period hours	9961	11048	2338
Unit load factor (ratio of average load to peak load for period)	0.747	0.783	0.667
Station - capacity factor (ratio of average load for period to rated capacity of units)	0.711	0.725	0.397
Station-use factor (ratio of generating hours to period hours)	0.794	0.783	0.541
Station-serviceability factor (ratio of availability hours plus generating hours to period hours)	0.884	0.829	0.873

due to this unit being the first placed in service. The experience gained from its operation, maintenance, and inspection served to improve the performance of the other units. The ability to do maintenance during periods of ample hydro generation, when steam units are not required to meet system load, is reflected in the number of hours the units are unavailable being larger than would be the case for the same units in a predominantly steam system. This is true because all maintenance time, when the units are shut down, is charged to "hours unavailable," even though the unit would not be required to meet system loads. Also, when there is ample hydro, steam-plant maintenance has been done on a single shift instead of a two- or three-shift basis, thus increasing the elapsed time chargeable to "hours unavailable." Therefore the "station serviceability factor" indicates a lower index of operating performance than actually exists for the service required of the units.

PERFORMANCE OF UNIT B

The performance of Unit B for one year ending May 31, 1943, is shown graphically in Fig. 4. It is to be noted that the trend of the net plant heat rate indicates an improvement in the performance of approximately 500 Btu per kwhr during the year, resulting from adjustment of equipment and from experience gained by the new plant personnel. This seasoning period is inherent to all new steam-power generating plants and the lower operating efficiency during this period may rightly be considered as one of the costs of making the development.

During the period covered in Fig. 4, the station use factor was 78.3 per cent and the station serviceability factor was 85.2 per cent.

GENERAL INSPECTION

On April 20, 1943, fourteen months after initial operation, Unit B was given its first complete inspection. The unit had operated 8527 hr and had generated 480,545,800 kwhr. It was found, in general, to be in excellent condition. Observations of particular note were:

1 Steam-generator pressure parts were clean internally and no scale, corrosion, or evidence of metallic copper was noted. No wastage on the fire side of tubes in the primary furnace was found although the brown color and the character of slag, on both side walls of this furnace, were comparable to those reported in furnaces where wasting has occurred. Slag on the front and rear furnace walls was whitish, a good indication of the absence of conditions for external tube wastage. At this same time, an inspection of Unit A boiler was made, showing its condition to be similar to that of Unit B.

2 Samples from the superheater drains at 500 psi and at 125 psi, taken as the boiler was shut down after 12 days of service, showed pH of 6.3 and 6.5, and dissolved solids of 21 ppm and 25 ppm, respectively, indicating negligible carry-over.

3 The turbine condition was satisfactory, with clearances checking well, bucket erosion practically nil, and packing and glands in good condition. There was a very thin hard deposit on the buckets and diaphragm nozzles, this being most pronounced from the eleventh to the fourteenth stage. Analysis showed this to be approximately 61 per cent silica, 31 per cent R_2O_3 (aluminum and iron oxides) and 7 per cent combustibles, the silica being insoluble.

4 The condenser was clean and free from corrosion and erosion. During the entire period of operation, it has been tight and has delivered condensate with a specific resistance of 2×10^6 ohms.

5 The deaerating heater showed no pitting, accumulation of rust or scale, but did show a small amount of tube wastage at a tube support plate in the vent condenser.

6 The vent condenser of the evaporator preheater, which was built with copper U-tubes rolled into a steel tube sheet, showed tube wastage on the vapor side at the tube sheet. Analyses of tubes and deposits on the tube sheet and tube indicated this wastage to be a result of corrosion caused by corrosive vapors condensing on the tube sheet.

7 Inspections of other equipment disclosed no questionable conditions, although the turbine gland-seal piping contained considerable red-oxide scale. Several months prior to this inspection, pitting and corrosion of parts of pumps, handling water from the distilled-water storage wells, was noted. This water was shown to be corrosive, having a pH of about 5 and carrying 4 to 6 cc of oxygen. Treatment, by adding caustic soda to the storage wells, was inaugurated to raise the pH to 8.3, since which time no further corrosion has been observed. Gland-seal water is taken from these storage wells, and it is believed that the red oxide in the gland-seal piping was formed prior to the treatment of the water in the storage wells.

FEEDWATER CONDITIONING

The generally excellent internal condition of the equipment is attributable to the careful water conditioning which has been maintained. Raw water is taken from the reservoir at the hydro plant. It is treated at the steam plant with alum and sodium hydroxide and then filtered and treated with sodium zeolite before admission to the evaporator preheater, at which point it enters the feed cycle. Sodium sulphite and sodium hydroxide are added between the deaerator storage tank and the feed pumps. Sodium phosphate is pumped into the boiler. The cost of chemicals is about 75 cents per million kwhr. Representative conditions in the cycle are as follows:

(*a*) River water hardness (equivalent $CaCO_3$) ranges from 25 to 100 ppm, averaging about 60 ppm, and is mostly bicarbonate, with some calcium and magnesium sulphate, and a small amount of very fine silt.

(*b*) The pH of the river water ranges from about 7.2 to 7.5 before treatment. Optimum pH, before zeolite treatment and after filtering, is 6.5. After zeolite treatment, hardness is zero, with pH ranging from 6.4 to 6.9.

(*c*) Evaporator vapor, flowing to its condenser, the eighth-stage heater, has a pH of about 6.3. Evaporator concentration has been maintained at 2000 ppm. Blowdown is scheduled for every 4 hr for 8000 lb per hr load. There has been no scale accumulation on the tube bundle.

(*d*) Drains from the fifth- and eighth-stage heaters, com-

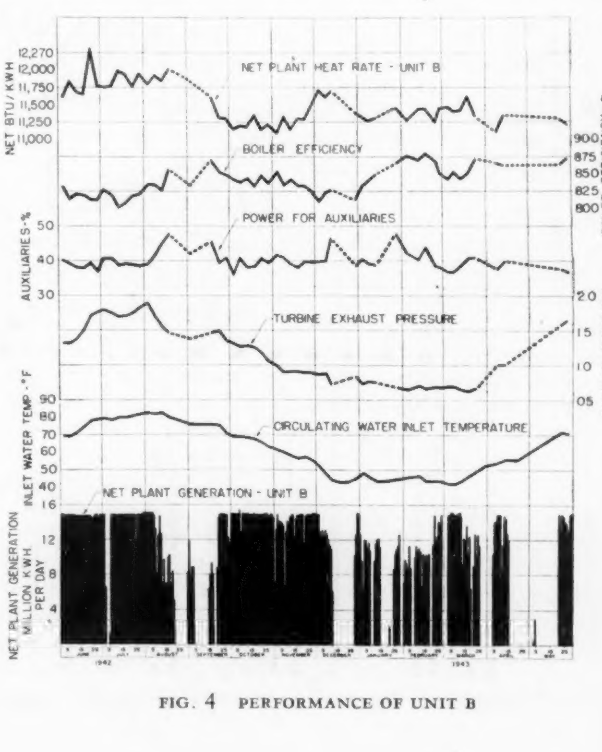

FIG. 4 PERFORMANCE OF UNIT B

bined, have shown pH, by spot checks, ranging from about 6 to 6.5 entering the deaerator.

(*e*) Condensate from the hot well has a specific resistance of 2×10^6 ohms, with a pH of 6.5 and oxygen of 0.03 cc per liter.

(*f*) Water from the deaerator storage tank, before addition of sodium sulphite and sodium hydroxide, has zero oxygen and a pH of 7, which is increased by introduction of the aforementioned chemicals, to within the limits of 8 and 8.6.

(*g*) Internal boiler-water conditions are maintained as follows by regulating chemical feeds and continuous blowdown which averages between 0.1 and 0.15 per cent:

Total dissolved solids.................	700 to 800 ppm
pH—minimum 10.6 normal............	above 11.5
Phosphate..............................	20 to 40 ppm
Sodium sulphite......................	15 to 25 ppm

The boiler water is practically free of sludge, contains some iron oxide, and the silica in it runs between 3 and 12 ppm, averaging 8 ppm.

FUEL BURNED

The varying quality and unpredictable character of the coals burned have made good boiler operation difficult, and the improving plant heat rate is due, in part, to the experience gained in burning these coals.

Coal supplied to the plant has come from 59 Kentucky and Tennessee mines, ranging in size from 0 to $^3/_8$ in. slack, to 4 in. and 6 in. run-of-mine, with about 20 per cent of the coal in the smallest range. The major receipts are from 20 mines, with about 10 per cent of the coal from one mine and about 5 per cent from a number of small local operations using truck delivery. The ash content in some coal, from small local operations, has been 29 per cent. Under such circumstances, constant inspection of coal quality has been required and control has been as rigid as conditions permitted.

In the period of November, 1942, to May, 1943, the coal burned averaged 12,960 Btu dry with 4 per cent moisture, volatile ranging between 28 per cent and 36 per cent, and averaging about 32.5 per cent, with fixed carbon averaging about 50.5 per cent and ash 13 per cent. Sulphur averaged about 2.75 per cent and the grindability index ranged between 45 and 80, averaging 60 to 65. Ash contents of the coals burned were about as follows:

5 per cent of the coal below 9 per cent ash
90 per cent of the coal between 10 per cent and 14 per cent ash
5 per cent of the coal above 14 per cent ash

The fusion temperature of the ash ranged between about 2150 F and 2350 F, and the fluid temperature between about 2250 F and 2450 F.

STARTING-UP AND SHUTDOWN PROCEDURE

Starting-Up Procedure. The present procedure in starting a boiler turbogenerator unit, from the time of first firing the boiler unit until the turbogenerator is carrying full load, is shown graphically in Fig. 5. The normal time for starting-up is about 12 hr, although these units have been started in 9 hr without any apparent difficulties. The large ratio of hydro capacity to steam capacity in the TVA system has not made it necessary to start the steam units in the shortest safe possible time.

Both duplex induced-draft and forced-draft fans are placed in service for about 10 to 20 min to purge the furnace of all explosive gases, after which one duplex induced-draft and forced-draft fan is shut down. This procedure is necessary to close

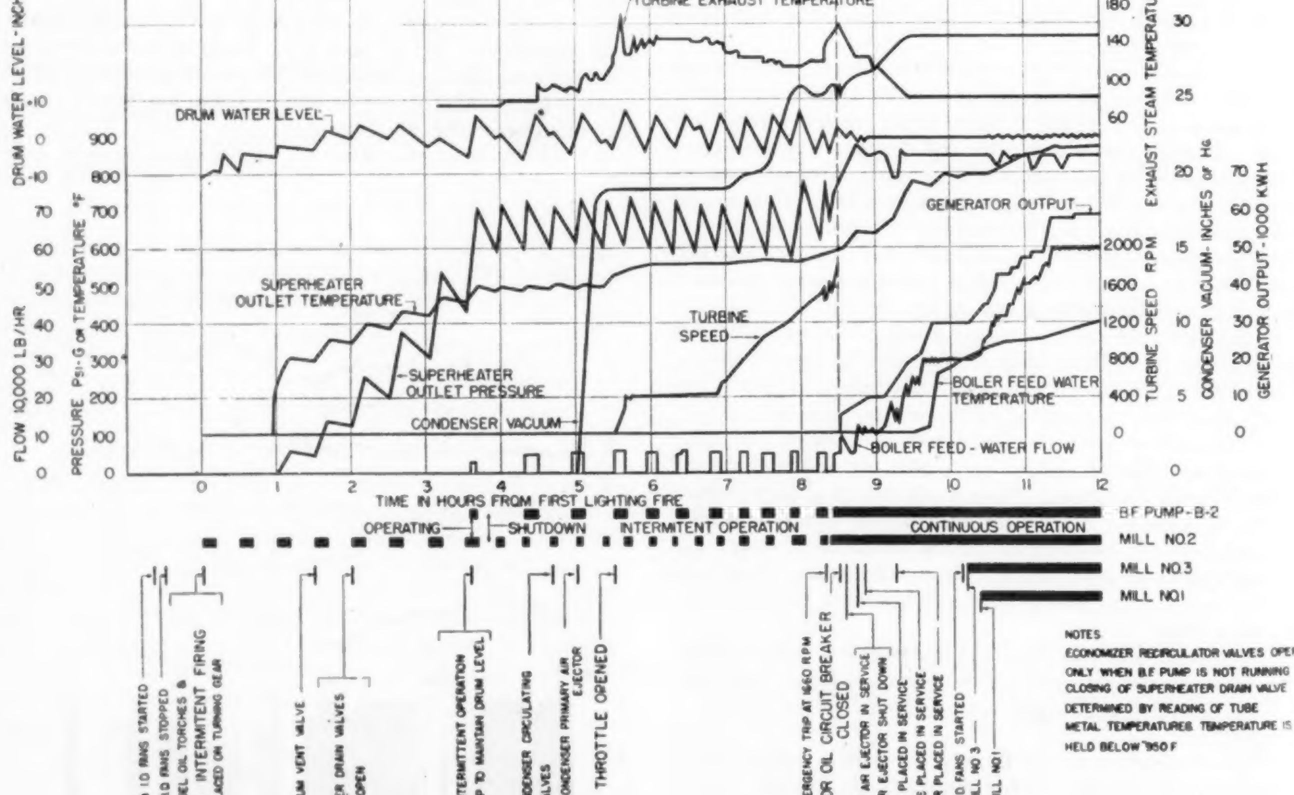

FIG. 5 STARTING-UP PROCEDURE

the contacts on the purge interlock equipment of the combustion control so that the fuel-oil lighting-off torches, feeders, and mills can be started. The lighting-off torches are kept lighted during the entire intermittent pulverizer-firing period until stable combustion conditions have been established in the primary furnace with two pulverizers operating and a load between 20,000 and 25,000 kw. One pulverizer is used until the load is built up to about 15,000 kw, when the second pulverizer is put into operation.

In lighting-off pulverized-coal burners, the operators prefer to start a mill and feeder and then to open primary air to have a mill differential of 0.6 to 0.8 in. to insure a rich coal-air mixture, and the resulting better ignition of the coal.

The superheater drain valves and drum vent valves are opened before initial firing. The drum vent valve is closed at about 60 lb pressure, and the superheater drain valves are closed to one turn open at 100 lb pressure. Further manipulation of these drain valves is determined by thermocouple reading of superheater-tube metal temperature at the bottom of the last boiler pass so as to maintain a metal temperature not to exceed 960 F.

The economizer recirculator valves, connecting the bottom and top of the economizer with the boiler lower drum and downcomers, respectively, are opened only while the boiler feed pump is not operating, and the economizer vent valve is opened at the same time. The boiler feed pump is not operated until sufficient steam has escaped through the superheater drain valves to lower the drum level 5 in. or more. The pump is operated intermittently as the boiler feedwater valve cannot regulate closely at the small flow required. The boiler is usually fired to give a uniform rise in saturated-steam temperature of 100 deg F per hr. Fig. 5 shows a rise of approximately 130 deg F per hr for about the first 4 hr, which is the manufacturer's recommendation of safe temperature rise to prevent excessive internal stresses in the boiler drums.

The turbine is placed on turning gear as soon as information is received from the load dispatcher that the unit is required. The primary single-stage steam ejector is used to evacuate the condenser in warming up the turbine and placing it on the line. This ejector has been designed for 150 lb steam pressure, so it would be possible to start warming up the turbine about 2 hr after initial intermittent firing, and thus bring the turbine up to speed and the boiler up to operating pressure simultaneously and in the minimum elapsed time, if the demand for load were urgent. After condensate is available, the two-stage steam-jet air ejectors and condensers are placed in service, and the primary ejector is shut down. The vacuum is maintained at about 18 or 19 in. for the first hour of operation with the turbine speed at about 400 rpm to reduce vibration and to provide more even heating of the rotor and casing. The emergency hand oil trip is tested at about 1660 rpm. The machine is not overspeeded each time it is started to check the overspeed governor.

The deaerator is put into service as soon as a positive pressure is obtained from the turbine extraction point after the generator has been placed on the line. The high-pressure heaters and evaporators are placed in service as soon as the load is sufficient to maintain enough pressure differential between the heaters and the deaerator to force the drains into the deaerator.

After the generator oil circuit breakers are closed, a load of from 5000 to 10,000 kw is carried for 30 min until the exhaust hood cools. Then increments of 5000 kw are added at 10-min intervals until the load of 30,000 kw is reached in $1^1/_4$ to $1^1/_2$ hr after closing the circuit breaker. This load is held for 30 min, and then the load is increased to full output in not less than $1^1/_2$ hr, or a total time from no load to full load of $2^3/_4$ to 3 hr. The supervisory instruments used to determine the operating condition of the machine greatly assist the operator in determining the time for putting the unit on the line. The foregoing schedule has resulted in satisfactory starting of the turbine.

Shutdown Procedure. The turbogenerator load is reduced to 30,000 kw by 5000- to 10,000-kw increments in not less than 45 min, after which the unit is operated at 30,000 kw for 30 min. From 30,000 kw the load is reduced to no load as rapidly as boiler conditions will permit. The oil torches are lighted on the last two mills when the load drops to about 20,000 kw. The coal feed is stopped to one mill at a time, and the mill is run until empty. After the last mill is empty and the burner flame is out, the drum pressure is dropped to 600 lb, with about 5000 kw on the turbine, before the generator oil circuit breaker is opened. The oil torches are shut off and the furnace purged for 10 min at maximum fan capacity.

As soon as the unit is off the line, the boiler is filled from the deaerator storage tank to 20 in. above normal water level and the boiler feed pump is shut down. As the boiler cools, the water level drops in the drum, and it is necessary to restore normal water about every 4 hr. At 50 lb pressure, the drum vent valve is opened. At zero drum pressure (about 12 hr after the unit comes off the line), the boiler is filled to 20 in. above normal drum level, the economizer recirculator lines are opened, and chemicals are pumped into the drum to remove oxygen and to reduce corrosion.

Unless inspection or maintenance work, requiring draining, is to be done, the boiler is left in this condition until it is next required for service. The operators plan to have a full storage tank of deaerated condensate when the unit comes off the line so this water can be pumped into the boiler to take care of the drop in drum level which results from the cooling of the boiler.

The turbine auxiliary oil pump is started as soon as the generator breaker is opened. At about one-half speed, the condenser vacuum is broken and the turbine comes to rest in about 15 min from the time the breaker is opened. The oil is cooled to between 85 and 90 F, the turbine is placed on the turning gear, and the auxiliary oil pump shuts down as oil is supplied to the bearings by the turning-gear pump. The circulating water is left on the condenser for 3 or 4 hr to reduce turbine-casing temperature.

EXPERIENCE OF INTEREST TO THE DESIGN ENGINEER

During the first year of operation, a few difficulties were experienced with the steam generator and its auxiliaries, all of which are being corrected or have been corrected. These can be stated briefly as follows:

(*a*) *Boiler Efficiency.* The water spray nozzles for the dust chamber at the bottom of the second boiler pass were originally supplied with water at 90 to 100 lb pressure. Under this pressure the spray was atomized sufficiently for it to rise into the gases at the bottom of the second pass and be picked up and evaporated. A "fog" could be clearly seen rising into the gas flow when it did not turn into the third pass before reaching down to the dust-chamber throat. The water vapor picked up by the gas was at times as great as 0.4 lb of water per lb of coal burned. This moisture in the flue gas affected the air-flow measurements of the combustion control and the superheat, and cost 3 to 4 points of boiler efficiency and lowered the dew point of the gases, affecting air-heater cleanliness. Starting in April, 1943, the water pressure on the dust chamber sprays was reduced to 10 psi. The "fog" condition at the throat of the dust chamber disappeared and operating efficiency and superheat control improved noticeably when the spray water pressure was reduced.

(*b*) *Air Heaters.* Prior to the reduction in the dust-chamber water spray pressure to 10 psi, air preheaters were fouling to an extent requiring washing every 3 months. After reduction in the water spray pressure, the pressure differential across the air heaters did not change noticeably; all indications pointed to a considerably lengthened period between washing of these heaters.

(*c*) *Steeple Tube Protectors.* The tubes in the roof of the pri-

mary furnace between which the pulverized coal is blown into the furnace are protected from abrasion by wedge-shaped metal castings spot-welded to the boiler tubes. These protectors are abraded by the coal stream, and the extent of this action may cut through the protector and expose the furnace tube to the abrasive action of the coal stream. As the condition of the steeple tube protectors cannot be satisfactorily examined with the boiler in operation, it naturally is a matter of concern to the operating personnel to know to what extent abrasion has progressed. Under these conditions, steeple tube protectors have been replaced about every 3 to 4 months, when the unit has not been required, so as to safeguard future continuous operation. Experiments are being made to extend the life of these protectors, by changing their shape and the metal of which they are made.

(*d*) ***Induced-Draft Fans.*** Induced-draft-fan inlet boxes, housings, and housing, liners have been abraded sufficiently in 4 to 5 months to require repairs. The operating time between repair periods can be lengthened by the use of thicker liner plates. Wartime material restrictions have made it difficult to obtain proper material for liners to provide for maximum life. The wheels and shafts of the fans are in excellent condition and show no significant wear.

(*e*) ***Pulverizers.*** The pulverizers have operated with reasonable maintenance, giving excellent pulverization with power consumption about 16 kwhr per ton of coal. Although three pulverizers will handle full generator output, it is the operating rule to have four mills in service for full load.

The pulverizers have started hard after a shutdown period during which they have had time to cool. This condition has been caused by coal packing under the driving yoke during operation and freezing the yoke to the pulverizer frame when the vertical shaft contracted in cooling.

FUTURE PLANT PERFORMANCE

The performance data presented in this paper have been taken during the first 16 months of the plant operation during which the plant equipment was in the process of adjustment and the personnel was being trained. Accordingly, it is difficult to indicate accurately the normal future performance to be expected of a plant of this design.

Results for the last 10 days of May, 1943, when minor difficulties in plant design had been corrected and all three units in the plant were operating, indicate steady full-load performance. The average performance of Unit A which carried the heaviest load during this period and the average performance of the plant are tabulated in Table 3. It is to be expected

TABLE 3 AVERAGE[a] OPERATING DATA FOR 10-DAY PERIOD, MAY, 1943

	Unit "A"	Plant average[b]
Generator output, kw	64000	61800
Station use, per cent	4.03	4.03
Exhaust pressure, in. hg abs	1.64	1.58
Net Btu per kwhr	11280	11320
Circulating-water, inlet, deg F	71	71
Boiler output, lb per hr	577000	558000
Superheater outlet pressure, psig	860	861
Superheater outlet temperature, deg F	895	889
Feedwater temperature to economizer, deg F	407	407
Preheater outlet gas temperature, deg F	344	344
Boiler efficiency, per cent	88.7	88.3
Evaporator feedwater make-up, per cent	0.93	1.17

[a] Plant average based on three units, 180,000 kw.
[b] Average per unit installed.

that the net plant heat rate during winter operation and when operating at the load for best efficiency discussed earlier in this paper will show improvement of the figures tabulated. The data shown in Table 3, and the individual tests of one unit, mentioned earlier, indicate plant performance exceeding the best results expected when designing the plant, and it should perform its function satisfactorily in the TVA system as an economic source of steam-electric power.

Comment by George R. Rich[3]

The authors have prepared a very interesting account of the performance of Watts Bar Station, and I should like to take this opportunity to make acknowledgment of the consulting service rendered by their firm in connection with the engineering design of the project. The net station heat rate in the vicinity of 11,200 Btu per kwhr, appearing consistently in the daily plant logs, attests the skill with which the engineers of the operating department of the Authority have handled these generating facilities.

One of the most important factors in meeting the accelerated design schedule was the assistance of the major equipment and piping contractors. Immediately following the contract awards, these companies sent specialists to work intensively with the designers, permitting crystallization of the essential arrangement and basic heat balance of the station in the first week of activity. This procedure insured full benefit in subsequent detailed design and procurement from the use of standardized equipment and a simple standardized cycle of demonstrated effectiveness.

Since the subsequent successful installation of several 3600-rpm turbogenerators in capacities in the order of 60,000 kw, the question frequently arises as to why 1800-rpm units were selected for Watts Bar. The pertinent facts are (1) that an 1800-rpm machine was in fabrication in the shops and could be commandeered, and (2) that no 3600-rpm units of comparable size other than the Los Angeles unit were on order at that time. Consequently, those responsibly concerned in the Authority did not incline to what, at that time, might have been considered pioneering. In the case of the subsequent units to be installed, the necessity for the greatest speed in wartime construction and engineering dictated duplication of the identical design and equipment employed for the first unit installation. If it were not for the last requirement, very serious consideration would certainly have been given to the purchase of the lighter tandem-compound-type 3600-rpm machines. To prevent any possible misunderstanding, however, it is definitely stated that the 1800-rpm units have been eminently satisfactory in every respect.

It will be noted that single-pass instead of two-pass condensers were selected. In this connection, it should be emphasized that whatever role may develop to be most advantageous for the future permanent operation of the station, an advance assumption had to be made prior to design, and in this case the layout was predicated upon an annual station use of 4000 hours. Under this premise the additional expense for the two-pass installation was not economically justified.

In conformity with the recommendation of the boiler manufacturer, no turbine-driven spare boiler feed pump is provided to maintain water level in the boiler drums in the event of sudden simultaneous loss of auxiliary power and the load on the generating unit. Because of the comparatively small amount of refractory material in the waterwall furnace, the heat residual following shutdown of the burners by electrical interlocking, while sufficient to cause the safety valves to open with a proportionate marked drop in drum level, is not either of sufficient duration or intensity to damage the steam generator.

In fact, in the opinion of the boiler contractor, lowering of level is less detrimental to the equipment than would be the sudden injection of relatively cold feedwater from the alternative design using the spare turbine-driven pump. During the preliminary operation period, before relay adjustments in the

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hydro control room had been perfected, an emergency of this very type occurred, and the results were substantially as predicted. About 40,000 lb of steam was released by the safety valves, practically emptying the drum but leaving 140,000 lb of water in the tubes.

Gravity feed for the circulating-water system was selected on the basis of an economic comparison in which the loss of revenue-producing water from the hydro system was included. The difference in capital cost from alternative systems, including pumps, was not significant, but it was considered that the operation and maintenance differential was in favor of the gravity system. This appears to be confirmed by the operating record to date. The discharge tunnel and canal arrangement is of interest. Optimum over-all economy appeared to result from a combination of depth of condenser-pit excavation and size of concrete pipe line that placed hydraulic gradient well above the top of the condenser shell for usual conditions, but called for operation as a siphon slightly below the hydraulic gradient for low reservoir levels of infrequent occurrence. This necessitated a seal for the outlet of the condenser, which is provided by incorporating a weir crest at a suitable level in the discharge canal. This arrangement also causes the discharge tunnel and canal to flow full with low velocities under all conditions, with resultant advantages from more stable, less erosive flow.

The foundation mats are about 7 ft thick, as compared with the usual value of 3 or 4 ft. In accordance with the well-known theory of beams upon elastic foundations, this increase in structural rigidity is provided to prevent excessive differential settlement and resultant misalignment of the generating machinery. This decision was reached on the basis of experience with identical shale foundation conditions for the Watts Bar navigation lock. The net increase in cost, in the order of $15,000, appears to be justified in view of the great stability of the foundation structure in actual operation.

Attitudes Toward Methods Improvement

(Continued from page 466)

No one group can bear the responsibility alone. We are *inter*dependent economically, and the responsibility must be shared by management and labor as well as by agriculture and government. It is the responsibility of management to prepare plans to convert individual plants and their equipment in order to reduce the transirion time from war to peace employment to as short a period as possible. It is the responsibility of labor to co-operate with management in making this conversion, and for studying union policies of apprenticeship and seniority so as to assist in the reabsorption of men returning from the armed services, and in the transfer of labor which will occur as between industries. It is also the responsibility of labor and management to see that the social-security and fiscal and tax programs of government are such as to eliminate the fear of involuntary unemployment, maintain consumption, and give incentives to new investment and new production.

In the past we have thought of "methods improvement" in terms of the particular industrial processes. In the future we must think also of methods of improvement in terms of the operation of the economy as a whole.

Security of employment is basic to any effective and efficient reconstruction policy whether for a single company or for the nation. Every business enterprise must accept clear responsibility for planning *its* operations in a manner that will provide continuous employment at steady wages. A record of high turnover of labor in peace times must be universally recognized as a sign of business inefficiency. If business will seek to improve its administrative efficiency, I am sure that labor, and particularly organized labor, in good faith, will continue to co-operate for the improvement of production efficiency. The two are inseparable.

Methods Improvemeut From the Viewpoint of the Consultant

(Continued from page 464)

gether develop procedures for doing it with the maximum benefit to all concerned. They should endeavor to work out an acceptable formula for disposing of the savings resulting from improved methods, and should seek to develop ways of introducing improved methods which will not constitute a threat either to the security of the worker or to the competitive position of the company.

With these safeguards developed, it would seem to be labor's turn to exercise its leadership and to take the initiative in eliminating "make-work" practices which in the long run if unchecked will sap the vitality from our productive enterprise.

Then finally when management and labor have demonstrated their ability to get together on a program of general methods improvement, the government, with the support of a public opinion enlightened by both management and labor, should eliminate its own ineffective, make-work practices and join in the march toward greater productivity through better methods.

This is an ambitious program, to be sure, and viewed in the light of immediate problems will undoubtedly be difficult to carry out in its entirety. The day is coming, however, when American industry will wish to compete in free world markets without lowering its standard of living to the levels of less advanced peoples. How else can this be accomplished other than by becoming more productive? The strength of America in the future will lie in its ability to produce.

Methods Improvement From the Viewpoint of Management

(Continued from page 468)

the maximum benefits from our methods-improvement program. We must provide the opportunity for them to participate in the program to the degree that the nature of the manufacturing process and other factors make practical. This participation can vary all the way from the minimum point of keeping the employees fully informed of all progress as the program develops and encouraging them to make suggestions with suitable rewards for accepted ones, to the maximum degree where they select representatives to work full or part time with the technicians and the supervision on the solution of the production problems involved, and aid in the preparation of the recommendation finally made to the general management for acceptance and approval.

It can then be seen that if each phase of a particular problem is carefully analyzed and proper policies and plans laid down, proper working relationships between the various groups in the organization defined and co-ordinated, we are ready to proceed on a sound basis with our methods-improvement program.

We then have the opportunity to increase our productivity, lower our costs, maintain or improve our wage levels, lower our sales prices, and in that manner not only place our own establishments in a sound competitive position, but also make our full contribution to the economic welfare of our country and aid it in fulfilling its responsibilities in the economic development of the world.

Rationalizing

THERMAL-INSULATION DIMENSIONS

By RAY THOMAS

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THERMAL insulation, while dating back many years in loose form, has only within recent years become a dimensional product. This is a natural situation when its increasing importance to design and engineering in industry is considered. The days of "getting away with some pipe covering" are fast disappearing, and the following information is presented to indicate some advantages of having a simple, direct, and definite scheme with which to design and order pipe insulation.

Following the completion of a large Middle Western manufacturing plant during 1935, in the construction of which the author was charged with the responsibility for specifications, designs, bills of material, and application of the thermal insulation, a study was made of insulation dimensional characteristics from which to develop a chart to bill materials. The initial study resulted in the development of new materials, discarding of some, and revising of others. The main thought was to reduce the number of sizes, thicknesses, and types of insulants to a minimum and, if possible, to co-ordinate different types so that, when desired, a more complete interchange might be accomplished. Such interchange, between those materials of nominal thickness (such as standard and double standard) and those furnished 1 in. thick or more in $^1/_2$-in. increments, is not possible at the present time.

This work was independently conducted until 1939, when an affiliation with others similarly interested afforded an opportunity to expand the study of dimensions. At recent meetings, the majority of this group decided that any move at the present time toward making this change might conflict with the war production; however, they went on record as favoring an intensive study to bring this program to a satisfactory conclusion as soon as possible so that it would be available for postwar production.

Probably one of the most difficult phases of handling insulation in an industrial plant is the constant endeavor to maintain an adequate but minimum stock. After a period of time, a considerable quantity of the stock on hand is made up of leftover odd sizes. The odd sizes not used in current work, if stored so as to be accessible, often require an excessive amount of space. The space and clerical force ordinarily allocated to work of this kind

PROPOSED BASIC SIZES OF INSULATION FOR PIPING AND TUBING

Pipe Size		Nominal 1" Thick		Nominal 1½" Thick		Nominal 2" Thick		Nominal 2½" Thick	
N.	OD.	THK	OD.	THK	OD.	THK	OD.	THK	OD.
¼	.540	1.142	2.875	1.453	3.500	1.953	4.500		
⅜	.675	1.076	2.875	1.641	4.000	2.141	5.000		
½	.840	1.000	2.875	1.562	4.000	2.062	5.000		
¾	1.050	.910	2.875	1.437	4.000	1.937	5.000		
1	1.315	1.092	3.500	1.562	4.500	2.093	5.562		
1¼	1.660	.930	3.500	1.625	6.000	1.906	5.562		
1½	1.900	1.031	4.000	1.531	5.000	1.844	5.562		
2	2.375	1.031	4.500	1.562	5.562	2.094	6.625		
2½	2.875	1.031	5.000	1.312	5.562	1.844	6.625		
3	3.500	1.000	5.562	1.531	6.625	2.031	7.625		
3½	4.000	1.281	6.625	1.281	6.625	1.776	7.625		
4	4.500	1.033	6.625	1.531	7.625	2.031	8.625		
4½	5.000	1.281	7.625	1.281	7.625	1.831	8.625		
5	5.563	1.000	7.625	1.500	8.625	2.000	9.625		
6	6.625	.970	8.625	1.437	9.625	2.000	10.750		
7	7.625			1.500	10.750	2.000	11.750	2.500	12.750
8	8.625			1.500	11.750	2.000	12.750	2.687	14.125
9	9.625			1.500	12.750	2.187	14.125	2.687	15.125
10	10.750			1.625	14.125	2.125	15.125	2.625	16.125
11				1.625	15.125	2.125	16.125	2.625	17.125
12	12.750			1.625	16.125	2.125	17.125	2.625	18.125
14	14.000			1.500	17.125	2.000	18.125	2.500	19.125
15	15.000			1.500	18.125	2.000	19.125	2.500	20.125
16	16.000			1.500	19.125	2.000	20.125	2.500	21.125
17	17.000			1.500	20.125	2.000	21.125	2.500	22.125
18	18.000			1.500	21.125	2.000	22.125	2.500	23.125
19	19.000			1.500	22.125	2.000	23.125	2.500	24.125
20	20.000			1.500	23.125	2.000	24.125	2.500	25.125
21	21.000			1.500	24.125	2.000	25.125	2.500	26.125
22	22.000			1.500	25.125	2.000	26.125	2.500	27.125
23	23.000			1.500	26.125	2.000	27.125	2.500	28.125
24	24.000			1.500	27.125	2.000	28.125	2.500	29.125
25	25.000			1.500	28.125	2.000	29.125	2.500	30.125
26	26.000			1.500	29.125	2.000	30.125	2.500	31.125
27	27.000			1.500	30.125	2.000	31.125	2.500	32.125
28	28.000			1.500	31.125	2.000	32.125	2.500	33.125
29	29.000			1.500	32.125	2.000	33.125	2.500	34.125
30	30.000			1.500	33.125	2.000	34.125	2.500	35.125

Tube Size		Nominal 1" Thick		Nominal 1½" Thick		Nominal 2" Thick		Nominal 2½" Thick	
N.	OD.	THK	OD.	THK	OD.	THK	OD.	THK	OD.
⅜	.375	.969	2.375	1.531	3.500				
½	.500	1.142	2.875	1.453	3.500				
½	.625	1.076	2.875	1.641	4.000				
¾	.750	1.062	2.875	1.564	4.000				
¾	.875	.969	2.875	1.531	4.000				
1	1.000	.906	2.875	1.476	4.000				
1	1.125	1.157	3.500	1.657	4.500				
1¼	1.250	1.094	3.500	1.594	4.500				
1¼	1.375	1.031	3.500	1.531	4.500				
1½	1.500	.969	3.500	1.469	4.500				
1½	1.625	.906	3.500	1.657	5.000				
2	2.000	.969	4.000	1.469	5.000				
2	2.125	1.157	4.500	1.687	5.562				
2½	2.500	.969	4.500	1.500	5.562				
2½	2.625	.906	4.500	1.437	5.562				
3	3.000	.969	5.000	1.786	6.625				
3	3.125	1.187	5.562	1.719	6.625				
4	4.000	1.276	6.625	1.776	7.625				
4	4.125	1.219	6.625	1.719	7.625				
5	5.000	1.276	7.625	1.776	8.625	2.276	9.625		
5	5.125	1.219	7.625	1.719	8.625	2.219	9.625		
6	6.000	1.276	8.625	1.776	9.625	2.344	10.750		
6	6.125	1.219	8.625	1.719	9.625	2.281	10.750		
8	8.000			1.344	10.750	1.844	11.750	2.344	12.750
10	10.000			1.344	12.750	1.969	14.000	2.469	15.000
12	12.000			1.500	15.000	2.000	16.000	2.500	17.000
14	14.333			1.333	17.000	1.833	18.000	2.333	19.000
16	16.333			1.333	19.000	1.833	20.000	2.333	21.000
18	18.333			1.333	21.000	1.833	22.000	2.333	23.000
20	20.333			1.333	23.000	1.833	24.000	2.333	25.000
24	24.333			1.333	27.000	1.833	28.000	2.333	29.000

ABBREVIATIONS:

N. = NOMINAL PIPE SIZE.
OD. = OUTSIDE DIAMETER.
THK. = THICKNESS.

NOTE: ALL DIMENSIONS ARE EXPRESSED IN INCHES.

are not sufficient to cope with this situation efficiently. This is also true of the average supply house, contractor, and the smaller consumer. The accumulation of this large stock of material is additional evidence of the need which motivated the search for a means of minimizing and controlling such a situation. Substitutions caused by war-emergency restrictions bring to light still more vividly the need of a uniform system of dimensional standardization in order that materials might be used to better advantage.

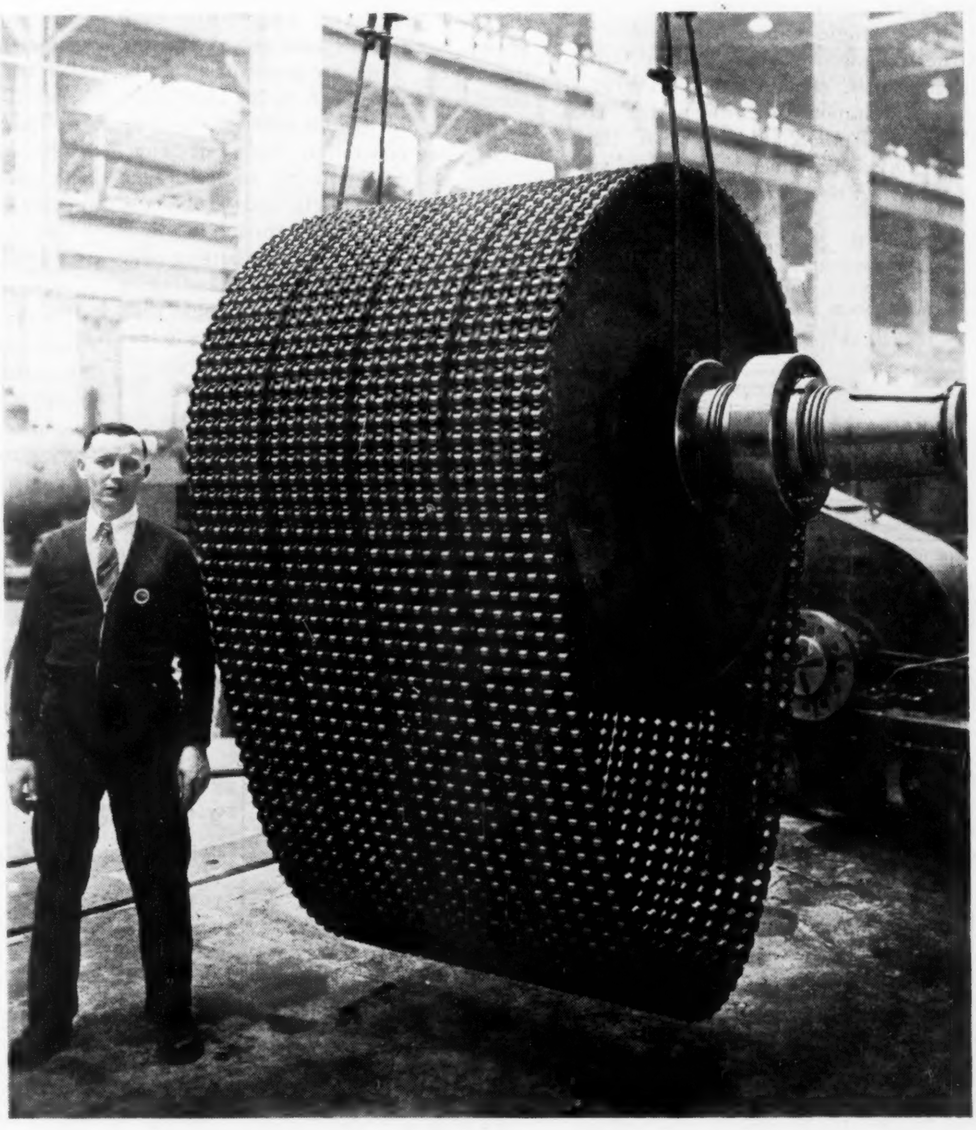
BASIC SIZES OF PIPE INSULATION PROPOSED

Tables representing materials now manufactured have been compiled by the author, from lists published in recent catalogues. This was necessary since no complete tabulation existed previously, due probably to the multiplicity of present thicknesses. A comparison of these complex tables with the accompanying proposed schedule, Table 1, revealed that a reduction of approximately 78 per cent could be effected in the number of pieces of pipe insulation required. In other words, out of a total of approximately 614 pieces of pipe insulation now available, a thickness of only 4 in. is obtainable. The proposed schedule, with only 135 pieces, however, provides all pipe sizes and any thickness within the scheduled range. (The author has compiled tables showing 20-in. thicknesses without the use of additional pieces.) Complete interchange of materials is also possible. The key to this simplification lies in the provision for outside dimensions of all pipe insulation to nest in some larger size.

The insulation, as proposed in this schedule, may be manufactured up to any desired thickness by cementing together a sufficient number of successively larger sections, or in one single layer. This schedule will not impose hardships on any manufacturer who finds it necessary to provide his customers with indispensable materials not listed. It would, however, accomplish one thing, namely, ***provide uniform dimensions for all manufacturers***.

It is the ultimate goal of the program to provide uniform thicknesses to be used by all manufacturers. As stated heretofore, the basis of this proposed schedule, in so far as pipe insulation is concerned, is to provide outside dimensions that will always fit the inside diameter of some larger pipe insulation. It will readily be seen that, where such a proposed schedule is followed, the odd sizes as now exist will be eliminated. The one great advantage is that, once it is established, the sections can always be used either singly or combined in layers with larger sizes to produce increased thicknesses. Sufficient flexibility has been maintained throughout to provide for any condition within reasonable limits.

It cannot be stressed too strongly that it is the author's desire to simplify pipe-insulation dimensions, without creating a burden on any manufacturer, consumer, or individual.



MARINE PROPELLER DRIVE

(Over ten thousand parts are assembled into this Morse Chain marine propeller drive for U. S. Navy 110-foot harbor tugs, largest application of its kind ever made. Exceptional efficiency, economy, and flexibility of engine-room layout are claimed. Smaller Navy vessels use similar applications, pointing the way to new performance efficiency on fishing boats, tugs, and Diesel driven cargo vessels.)

COMMENTS ON PAPERS

Including Letters From Readers on Miscellaneous Subjects

Cutting Tools

Comment by O. W. Boston[1]

This paper[2] should help manufacturing plants to use their cutting tools to much better advantage. The particular point of interest to the writer is that dealing with the proposed standard nomenclature of high-speed-steel single-point tools. The author proposes a new character, such as "S 15-25" to signify a side cutting tool with a 15-deg side cutting edge angle and a 25-deg end cutting edge angle, the letter S denoting the side cutting tool; end cutting tools being similarly denoted by the letter E.

There is at present an American Standard which covers terminology and definitions of single-point cutting tools for lathes, planers, shapers, turret lathes, boring mills, etc. (A.S.A. B5.13-1939). A second standard, dealing with "Tool Posts and Tool Shanks" (A.S.A. B5.2-1943), gives recommended standard sizes of tools. A new standard just approved

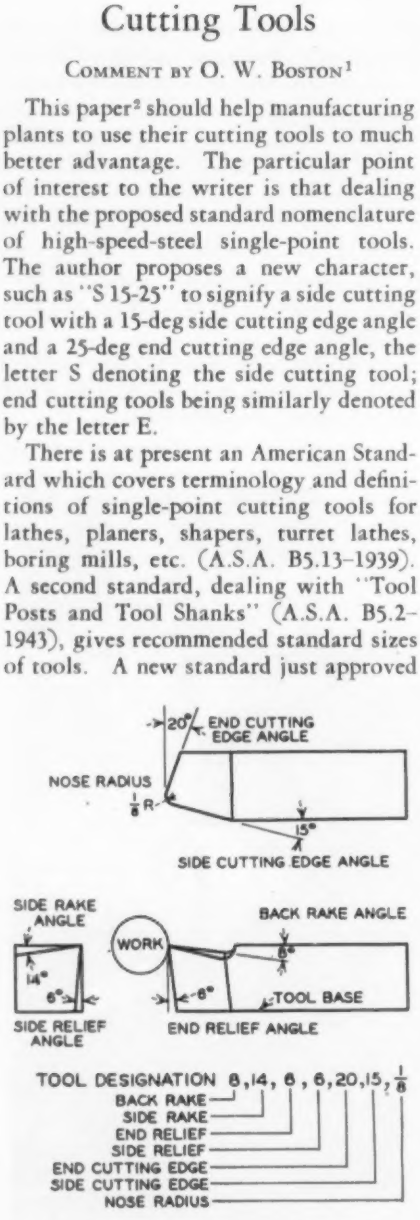


FIG. 1 A TYPICAL SOLID TOOL OF HIGH-SPEED STEEL GROUND FOR TURNING STEEL OF ABOUT 250 TO 300 BHN, SHOWING A CHARACTER WHICH COMPLETELY DEFINES THE SHAPE OF THE TOOL

by the committee charged with its development deals with "Tool Life Tests for Tool Materials Other Than Those of Sintered Carbides: A proposed standard of tool-life tests for evaluating the performance of single-point tools." This standard was presented by the writer as a paper at the Annual Meeting of this Society in 1943, in order that it might be brought to the attention of more people interested in the subject.

In this standard, as well as in many papers on the subject of metal cutting presented by the writer during the past dozen years, a key is suggested which gives the complete specifications of the tool in so far as its shape is concerned. This key is illustrated in Fig. 1 of this comment. It has been used successfully by the writer over a period of years in his own research work. It includes not only the back, side-rake, and cutting-edge angles, but also the nose radius, end and side relief. They are given in a specific order, such as 8, 14, 6, 6, 20, 15, $^1/_8$ in., indicating 8-deg back rake, 14-deg side rake, 6-deg end relief, 6-deg side relief, 20-deg end cutting edge angle, 15-deg side cutting edge angle, and $^1/_8$-in. nose radius, all illustrated in the figure. It is not uncommon to use a side cutting edge angle in excess of 45 deg; according to the author's table, this tool would then become an end cutting tool, whereas actually it is used as a side cutting tool.

As chairman of the Committee on Standardization of Tool Life Tests for Single-Point Tools, the writer regrets that the author of the paper has not been a member of this committee. It is hoped we may be enabled to work more closely together in the future.

Author's Closure

It seems to us that Prof. O. W. Boston takes a balcony panoramic view in his approach to cutting-tool standardization in relation to the paper on the subject under review.

Our approach was necessarily confined to the estimated needs of our particular company. Our objective was a steadier flow, in greater volume, of good aircraft-engine components through our production lines per unit of time, per machine tool. We therefore took our position on the production-line floor where the vista was a machine tool with an average operator in the foreground.

An investigation of his needs gave the point of departure:

He required an easy supply of identical reproductions of the tools in his setup, and available for instant replacement use without error.

Acting on the merits of the old Chinese proverb that "a picture is worth a thousand words," we prepared, for the man assigned to plot a setup, a series of sketches from among which he might select the appropriate style tools for the tool-position angles found, and the cuts to be taken. From the grouped sizes in the selection tables, he found the tool number against the style in that size.

We fixed upon designations, such as S-15-25, for convenience because our "standards" sketches, carrying these different designations can, and do, cover more than one tool size. Moreover, in the case of this S-15-25 style, it is pictured among the turning-tool sketches; we also find it sketched and shown as a facing tool, left-hand, of course. The same style appears among the boring tools, too. The tool-position angles where this designated-style tool can be effectively used is governed by the chosen lead angle, as illustrated in Fig. 2 of this closure. A typical standards sheet is shown in Fig. 3.

The plotting of a setup is thus a matter of visual selection for tool style; then from the selection tables the tool num-

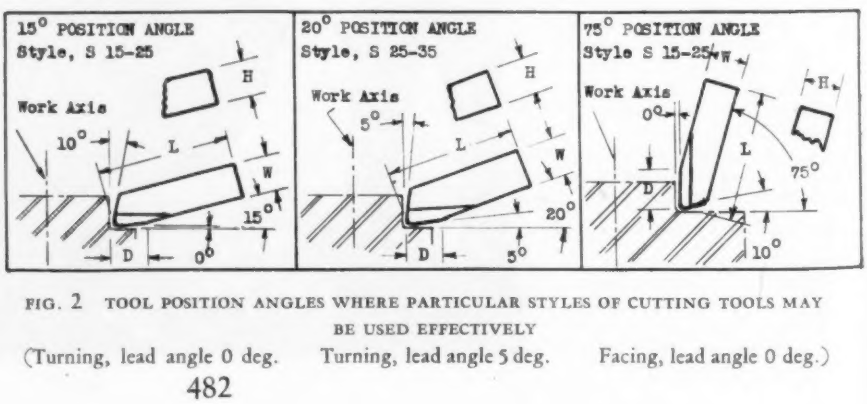


FIG. 2 TOOL POSITION ANGLES WHERE PARTICULAR STYLES OF CUTTING TOOLS MAY BE USED EFFECTIVELY

(Turning, lead angle 0 deg. Turning, lead angle 5 deg. Facing, lead angle 0 deg.)

[1] Professor of Metal Processing, University of Michigan, Ann Arbor, Mich. Mem. A.S.M.E.

[2] "Standardization of Cutting Tools," by Carl J. Wiberg, Mechanical Engineering, vol. 65, 1943, pp. 871-880.

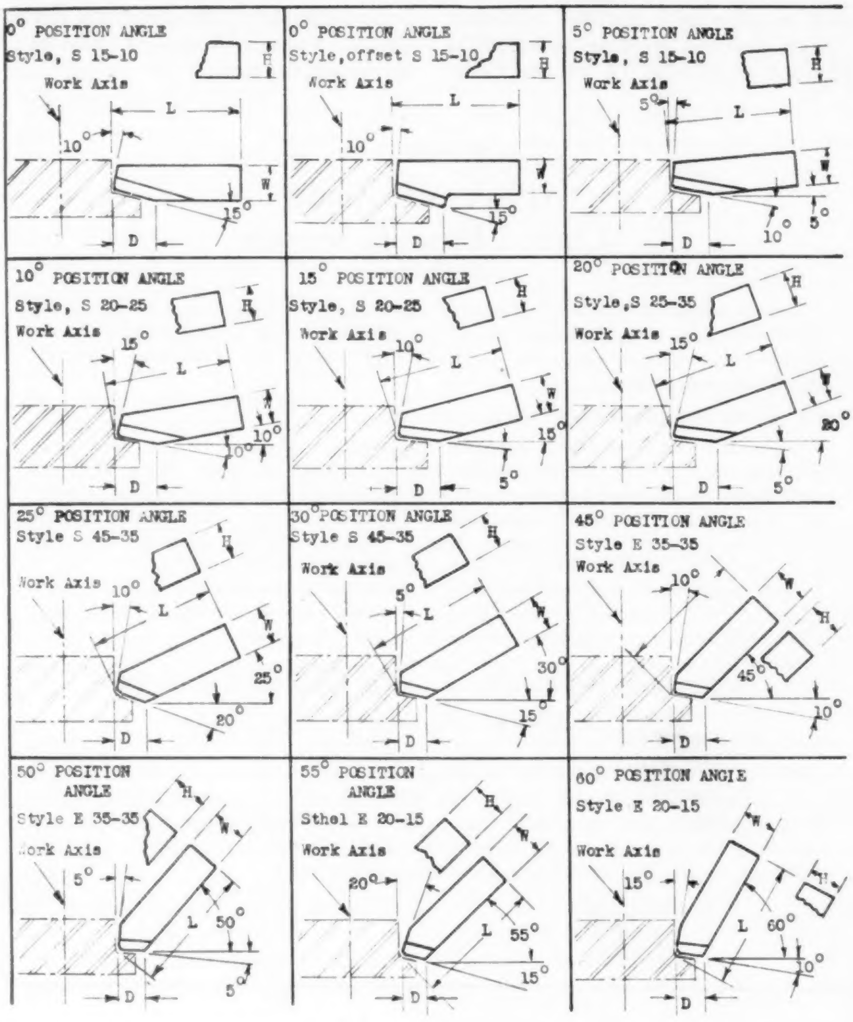


FIG. 3 TYPICAL TURNING-TOOL STANDARDS SKETCHES

bers identify the design listed against this style.

Designation 2T-80019 identifies one tool, a constant (see tool drawing, Fig. 7 of the paper). The only variable the operator may have to compensate for during that tool's usable life is the ± 0.005 nose-location tolerance.

We have thus approached one objective, i.e., an easy supply of identical reproductions of tools found in any setup, the whole being flexible, relatively simple, practical, and economical.

Perhaps Prof. O. W. Boston's objectives run parallel to, and aim at, a similar result.

Carl J. Wiberg.[3]

[3] Production Engineering Department, Wright Aeronautical Corporation, Paterson, N. J.

A.S.M.E. BOILER CODE

The Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Anyone desiring information on the application of the Code is requested to communicate with the Committee Secretary, 29 West 39th St., New York 18, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are then sent by the Secretary of the Boiler Code Committee to all of its members. The interpretation, in the form of a reply, is prepared by the Committee and is passed upon at a regular meeting.

This interpretation is later submitted to the Council of The American Society of Mechanical Engineers for approval and then issued to the inquirer and published in Mechanical Engineering.

Following is a record of the interpretations formulated at the meeting of April 21, 1944, and approved by the Council on May 19, 1944.

Case No. 1008

(Interpretation of Par. P-20)

Inquiry: Is the minimum plate thickness specified in Par. P-20 sufficient in the straight portion of a flanged tube sheet that is welded to the shell of a fire-tube boiler?

Reply: It is the opinion of the Committee that the specified minimums will meet the intent of the Code, provided that where the length of the straight portion of a flange exceeds $1^1/_2$ times the thickness of the tube sheet, the minimum thickness is at least 0.75 times the required thickness of the shell, based on the maximum allowable working pressure.

Case No. 1009

(Special Ruling)

Inquiry: Pars. U-76(*a*) and (*d*) and U-59(*p*) require, without exception, the stress-relieving of all welded connections. Not infrequently, it is necessary to weld on small connections to Pars. U-68 and U-69 vessels, after the vessels have been stress-relieved. May the stress-relieving of these added small connections be omitted?

Reply: It is the opinion of the Committee that such small connections need not be stress-relieved provided the hole in the shell required for attachment does not exceed that allowed for an unreinforced opening, but in no case to exceed 2 in. The inside and outside attachment welds shall not exceed a $^3/_8$ in. throat dimension. This interpretation does not apply to those connections so placed as to form ligaments in the shell, the efficiency of which will affect the shell thickness.

Case No. 1010

(In the hands of the Committee)

Case No. 1011

The following interpretation is printed for comment only. Communications should be addressed to the Secretary of the Boiler Code Committee, 29 West 39 St., New York 18, N. Y., in order that they may be presented to the Committee for consideration.

Inquiry: In locomotive fireboxes and combustion chambers equipped with staybolted syphons, a large portion of the crown sheet in a longitudinal direction is removed. The removal of this metal reduces the ligament strength of the remaining portion of the crown sheet and the added strength contributed by the syphon attachment may not compensate for this reduction. If this reduction in ligament strength causes localized stress concentrations in excess of the yield strength of the steel, an undesirable condition exists in the boiler structure. If this condition exists, how should it be corrected?

Reply: It is the opinion of the Committee that in the application of the Rules for Boilers of Locomotives the intent will

be met if the following requirements are complied with:

If more than 40 per cent and not more than 50 per cent of the total length of the crown sheet is removed, not less than 10 per cent of the removed longitudinal ligament shall be restored.

If more than 50 per cent and not more than 60 per cent, not less than 20 per cent shall be restored.

If more than 60 per cent and not more than 70 per cent, not less than 30 per cent shall be restored.

If more than 70 per cent, not less than 40 per cent shall be restored.

This is intended to apply to fireboxes, with or without combustion chambers, and for boiler pressures in excess of 180 lb.

If there are two or more syphons in longitudinal alignment, the total length of the slots shall be used in applying this rule.

The crown sheet slots for syphons shall be a sufficient distance from the door sheet and from each other longitudinally or diagonally to avoid undesirable localized stress concentrations, and a sufficient distance from the tube sheet to insure proper functioning of the crown sheet expansion stays.

If the ligament replacement is made by the addition of gussets welded across the top opening of the syphon, the welding shall be done by a qualified procedure and by qualified welding operators as provided in Section IX of the Code. Stress relieving of these welds is not required. Gussets, if applied, must be of firebox quality steel.

Supplement to the

API-ASME Code Unfired Pressure Vessels

(1943 Edition)

Since the publication of the first printing of the 1943 edition of the Code, the need for the following addition has come to the attention of the API-ASME Committee on Unfired Pressure Vessels. Holders of this edition are requested to note this addition. Extra copies of this notice may be obtained upon application.

Page 70, Par. W-524 a. Add the following:

NOTE: For vessels on which complete radiographic examination is not mandatory, credit for radiographing may be applied to separate elements of vessels, such as shell sections, formed heads, cone sections, manway assemblies and supports, as well as to complete vessels. The joint attaching such an element to an unradiographed element shall be examined as required by this paragraph, unless the thickness of the radiographed element at the joint is not less than that required for the unradiographed element.

Local employment of the radiographing credit shall be noted on the manufacturer's reports (See W-512) and the symbol XR shall be applied with the monogram (See W-529) only with information to identify the elements to which it applies.

Alternate Rules for Fusion-Welded Boilers 1943 A.S.M.E. Power Boiler Code

The Boiler Code Committee has formulated alternate rules for fusion-welded boilers based on Case No. 968. These rules, which will be an addition to the A.S.M.E. Power Boiler Code, have been approved by the Council as a standard practice of the Society. They are now available as addenda to the Code in pink-colored sheets and may be obtained upon request to the Publication-Sales Department of the Society.

REVIEWS OF BOOKS

And Notes on Books Received in the Engineering Societies Library

Durand Anniversary Volume

W. F. DURAND ANNIVERSARY VOLUME. Selected Papers of William Frederick Durand. Reprinted in commemoration of the eighty-fifth anniversary of his birth. By Durand Reprinting Committee, California Institute of Technology, Pasadena, California, 1944. Fabrikoid, $8^1/_4 \times 10^3/_4$ in., 127 pp., $2.50.

REVIEWED BY HUGH L. DRYDEN[1]

AS indicated by the title, this volume was prepared as a tribute to Dr. W. F. Durand, honorary member and past-president of The American Society of Mechanical Engineers, on his eighty-fifth birthday by Th. von Kármán, Clark Millikan, and E. W. Robischon. The principal content of the book is a group of 17 papers of general interest selected from the writings of Dr. Durand of which six are from MECHANICAL ENGINEERING, THE JOURNAL, and Transactions, A.S.M.E. In addition to these papers, the book contains an appreciation of Dr. Durand by Dr. Frank B. Jewett, president of the National Academy of Sciences; a biographical sketch of Dr. Durand prepared by Elliott G. Reid; and a complete bibliography of Dr. Durand's publications containing 243 entries.

A study of the bibliography indicates the remarkable versatility of Dr. Durand and the broad field of his interests. Even those of us who have known him for a long time as aeronautical engineer and expert in fluid mechanics are amazed to learn of four papers on biological subjects, the first in 1886 describing a parasite of Porcellio. The large number of important papers in marine engineering, hydraulic engineering, and aeronautical engineering testify to three careers, any one of which would be considered outstanding and meriting the highest honors.

The 17 papers reproduced in full in the book are worthy of careful study by all engineers as illustrative of clear thinking, of the scientific approach to engineering problems, and of inspiring presentation. Most of the content is still fresh after the passage of one or two decades. In particular the papers entitled "The Engineer and Civilization," "Science and Engineering," "Science and Civilization" give an evaluation of the role of the engineer in contemporary life and in the stream of history, of his duty and responsibility, and of his relationships to other members of society, which is as timely and helpful as when they were written.

[1] Chief, Mechanics and Sound Division, National Bureau of Standards, Washington, D. C. Mem. A.S.M.E.

Jacob Perkins

JACOB PERKINS: HIS INVENTIONS, HIS TIMES, AND HIS CONTEMPORARIES. By Greville Bathe and Dorothy Bathe. The Historical Society of Pennsylvania, Philadelphia, 1943. Cloth, 9 × 11 in., xiv and 205 pp., illus., $5.

REVIEWED BY P. R. HOOPES[2]

JACOB PERKINS was an extraordinary man. Starting life as a self-educated New England mechanic, he developed, almost single-handed, the art of steel engraving and built that art into a successful international business; made important pioneer contributions to the application of automatic machinery in the metal-working industries; designed and built the first modern refrigerating machinery, the first successful uniflow engine, the central hot-air heating system, and a variety of high-pressure steam engines and boilers. He was recognized in both the United States and England as one of the foremost inventors of his time. Unlike Fitch, Evans, and Fulton, his career was notably free from quarrels over priority. He was generous with assistance to other engineers and enjoyed the friendship of most of the eminent American and English mechanics of the first half of the nineteenth century.

The present book is essentially a record of Perkins' inventions, based upon patents, periodicals, pamphlets, and broadsides published during the inventor's lifetime. Manuscript sources are few and no letters were found to reveal the man himself. The result is a somewhat impersonal chronicle which recreates the story of Perkins' accomplishments as they were known to his contemporaries. Of his mental processes, unsuccessful experiments, the influences which directed his efforts and the personal, financial, and technical difficulties, which are the inevitable accompaniment of invention, practically nothing appears.

The record is nevertheless a most interesting one. The authors have organized their material with skill, have shown excellent judgment and discrimination in the use of extended quotations from original sources, have identified their authorities, and have produced a work of which they have every right to be proud. It is a sound historical study, an exceedingly entertaining book, and a beautiful example of typography.

In gathering material for this book the authors leaned heavily upon the Taylor papers in the library of the American Antiquarian Society. It is to be regretted that they overlooked the Perkins collection gathered by the American Bank Note Company and that war prevented any systematic search for manuscript sources which doubtless exist in England. A number of references in contemporary American periodicals seem to have escaped notice, and it is permissible, perhaps, to differ with some of the authors' conclusions. On the whole, however, the work is a welcome and important contribution to knowledge of the history of American engineering. The edition is limited to two hundred copies and the book will therefore be unobtainable by all but a few fortunate libraries.

[2] Consulting Mechanical Engineer, Philadelphia, Pa. Mem. A.S.M.E.

BOOKS RECEIVED IN LIBRARY

PATENTS AND INDUSTRIAL PROGRESS. By G. E. Folk, with a foreword by R. L. Lund. Second edition. Harper & Brothers, New York, N. Y., and London, England, 1942. Cloth, $5^1/_2$ × 8 in., 393 pp., diagrams, charts, tables, $3. One specific duty assigned to the Temporary National Economic Committee, when it was created in 1938, was that of investigating our patent system, with a view to improving the patent laws. At its hearings much testimony was presented by the Department of Justice, the Department of Commerce, and the industries. In this volume this testimony is summarized, analyzed, and evaluated by an experienced patent attorney.

POWER AND FLIGHT. By A. Jordanoff. Harper & Brothers, New York, N. Y., and London, England, 1944. Cloth, 7 × 10 in., 314 pp., illus., diagrams, charts, tables, $3.50. A readable, elementary text on the aircraft power plant and its maintenance, intended for students and mechanics. It will also be useful to others who wish to know something about aircraft engines. The book is distinguished by over four hundred illustrations which clarify the text.

PRACTICAL DESIGN OF WELDED STEEL STRUCTURES. By H. M. Priest. American Welding Society, New York, N. Y., 1943. Cloth, 5 × 8 in., 153 pp., illus., diagrams, charts, tables, $1. The essentials of welding and welded construction are presented in concise form as a working manual for the practical welder and designer. The various welding processes, forms of joints, and weld testing are discussed. The general and detail design considerations for simple welded joints and connections precede their application to typical structural members. A separate chapter is devoted to the problem of fatigue.

PRECISION MEASUREMENT IN THE METAL WORKING INDUSTRY, vol. I, prepared by the Department of Education of International Business Machines Corporation. Syracuse University Press, Syracuse, N. Y., 1942. Cloth, 8 × 11 in., 263 pp., illus., diagrams, charts, tables, $2.75. This is a revised edition of the manual on precision measurement and inspection methods in metalworking originally prepared for use in training International Business Machines Corporation workers. Volume one contains the first seven chapters, dealing with measurement in general, nonprecision line-graduated instruments, micrometer and vernier types, precision-gage blocks, fixed gages, thread gages, dial gages, and test indicators. Volume two, now in process, will treat the more advanced types.

RUBBER RED BOOK, Directory of the Rubber Industry, 1943 edition, fourth issue. Published biennially by *The Rubber Age*, New York, N. Y. Cloth, 6 × $9^1/_2$ in., 579 pp., illus., $5. This directory of the rubber industry lists the rubber manufacturers of this country and Canada, the manufacturers of rubber machinery and accessories, the suppliers of chemicals, fabrics, and crude rubber. The varieties of synthetic rubber and their makers are listed. Other listings include rubber reclaimers and scrap dealers, rubber derivatives and rubber latex, consultants, sales agents, technical journals, organizations, and a directory of men prominent in the industry.

STATISTICAL ADJUSTMENT OF DATA. By W. E. Deming. John Wiley & Sons, Inc., New York, N. Y.; Chapman & Hall, London, England, 1943. Cloth, $5^1/_2$ × $8^1/_2$ in., 261 pp., diagrams, charts, tables, $3.50. This is a practical reference and textbook on the adjustment of data, with emphasis on scattered portions of the subject that are difficult to find elsewhere and that, in the author's opinion, are becoming increasingly important. Different kinds of problems of adjustment are unified and brought under one general principle and solution. Statistical procedures for curve fitting and other adjustments by least squares are discussed.

STRENGTH OF MATERIALS. By H. F. Girvin. International Textbook Co., Scranton, Pa., 1944. Cloth, 6 × 9 in., 357 pp., illus., diagrams, charts, tables, $3. After a survey of the first sources in strength of materials given at our larger colleges, Professor Girvin has prepared this textbook. It aims to give the student thorough training in basic principles and to avoid attention to specialized topics which are better treated in later courses in design. The area-moment method of determining deflections is emphasized. A large number of problems are included.

THEORY OF THE GYROSCOPIC COMPASS AND ITS DEVIATIONS. By A. L. Rawlings. Second edition, completely revised and reset. The Macmillan Company, New York, N. Y., 1944. Cloth, $5^1/_2$ × $8^1/_2$ in., 182 pp., illus., diagrams, charts, tables, $3. The theory of this compass is presented by an authority who has invented various important improvements. Included are descriptions of the Sperry, Anschütz, Arma, and other models in use today. Navigators and men concerned with the installation and maintenance of gyrocompasses and advanced instructors in schools will want the book. This edition has been revised and extended, and made simpler than the previous one.

TWENTIETH CENTURY ENGINEERING. By C. H. S. Tupholme. Philosophical Library, New York, N. Y., 1944 Cloth, $5^1/_2$ × 9 in., 201 pp., illus., diagrams, charts, tables, $3. Intended to give the layman an account of "some of the more spectacular engineering progress during recent years," this work deals with developments in mechanical power, workshop processes, air-conditioning, refrigeration, chemical and metallurgical engineering, electrical engineering, traction, marine engineering, aircraft, and physics.

WHITE METALLING. By H. Warburton. Emmott & Co., Ltd., Manchester and London, England, 1944. Paper, 5 × $7^1/_4$ in., 80 pp., illus., diagrams, tables, 2s. The white-metal alloys used for lining bearings are described and directions given for relining bearings. The methods are described clearly and practically, and much information is presented.

A.S.M.E. NEWS

And Notes on Other Engineering Activities

A.S.M.E. Aviation Division Holds West Coast Meeting at the University of California, Los Angeles

June 5–8, Inclusive

THE A.S.M.E. Aviation Division opened its West Coast Meeting on June 5, practically simultaneously with the Allied invasion of Hitler's European Fortress. Over 800 engineers, however, forsook their radios to attend twelve technical sessions of the meeting.

The meetings were held in the Chemistry Building at the University of California in the evenings of the four days. Thus the evening sessions were arranged to fit the crowded schedules of the aeronautical engineers in Southern California.

The "keynote" of the meeting was the "strictly business" attitude of all those attending. There was practically no visiting from session to session, and those who attended a session stayed to the end. It was observed that most engineers carried notebooks and were busy on them throughout the session.

Summary of Sessions

Particular attention was given to production problems in the aircraft industry with three panel-discussion sessions scheduled covering master tooling, contour engineering, and production design. In a fourth production-engineering session, important papers dealing with special aircraft problems involving milling-machine operations were discussed. Large attendance and extended discussions of controversial questions of vital importance in aircraft production were the outstanding features of these sessions.

Two sessions on applied mechanics dealt largely with problems concerned with the structural-strength characteristics of primary aircraft components. In a heat-transfer session, special problems relating to heat-exchanger design, aircraft windshield de-icing, and the like were discussed. Aircraft materials and processes received considerable attention in two sessions on metals engineering and one on rubber and plastics, while a final session on education brought together engineering teachers and representation of industry for a discussion of some of the problems of engineering training peculiar to the aircraft-manufacturing field.

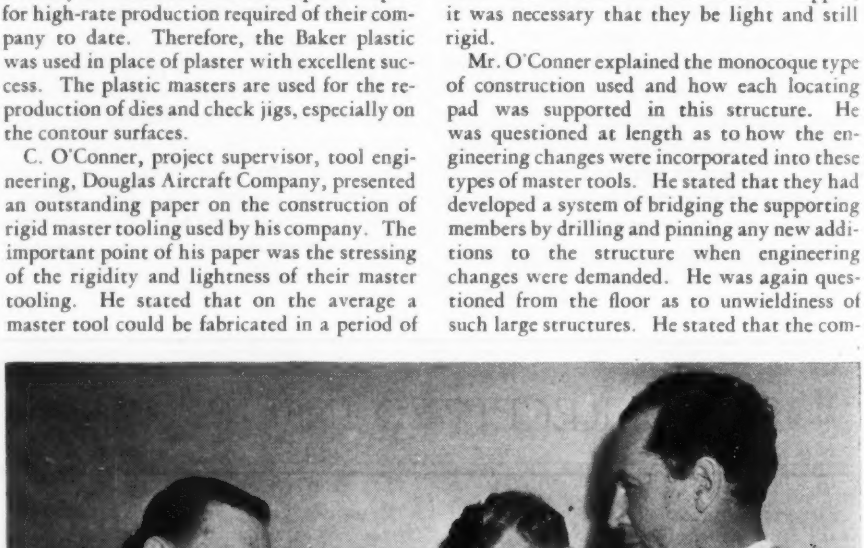
Master Tooling Panels[1]

The panel for discussion on master tooling consisted of John S. Haldeman, E. P. Myers, and C. O'Conner; other members of the panel were absent because of emergency calls from their companies.

John S. Haldeman, division manager of tool engineering, Lockheed Aircraft Company, Plant A, made an excellent presentation of plastic masters as they are used at the Lockheed plants at Burbank, Calif. He stated that the original masters were made of plaster, the accuracy of which could not be depended upon for high-rate production required of their company to date. Therefore, the Baker plastic was used in place of plaster with excellent success. The plastic masters are used for the reproduction of dies and check jigs, especially on the contour surfaces.

C. O'Conner, project supervisor, tool engineering, Douglas Aircraft Company, presented an outstanding paper on the construction of rigid master tooling used by his company. The important point of his paper was the stressing of the rigidity and lightness of their master tooling. He stated that on the average a master tool could be fabricated in a period of three or four days from the receipt of engineering prints. This master tool would carry all the critical points of the structure, that is, attached fittings and butt joints for that particular assembly. By the use of the master tool they could fabricate as many assembly jigs as were necessary to meet their production schedule or could ship the master to any part of the country where subcontract work was being done. Because these masters had to be shipped, it was necessary that they be light and still rigid.

Mr. O'Conner explained the monocoque type of construction used and how each locating pad was supported in this structure. He was questioned at length as to how the engineering changes were incorporated into these types of master tools. He stated that they had developed a system of bridging the supporting members by drilling and pinning any new additions to the structure when engineering changes were demanded. He was again questioned from the floor as to unwieldiness of such large structures. He stated that the com-



GROUP ATTENDING A.S.M.E. AVIATION MEETING IN LOS ANGELES

(*Left to right:* Prof. Thomas A. Watson, of the University of California; Dr. John E. Younger, of the University of Maryland and Secretary of the Aviation Division; Prof. M. J. Thompson of the University of Texas; and Timothy E. Colvin, general chairman of the meeting.)

[1] Compiled by T. A. Watson, chairman of the session. Mem. A.S.M.E.

pany agreed that many of the masters had been unwieldy and therefore have now been broken down to submasters. In his opinion, the record of production of his company indicates that this system has worked out to some advantage.

E. P. Myers, chief tool engineer of Consolidated-Vultee Aircraft Company, San Diego, California, presented an excellent paper on the tooling dock and described his company's activities in the use of this unit. He stated that in his opinion the use of rigid masters for large airplanes was completely out. He gave one example to illustrate this point, namely, the construction of a nose master for the B-24 which became so unwieldly in regard to its use that it was necessary to take the jig to the master instead of the master to the jig. The company had spent well in excess of $80,000 in its construction and then engineering called for a change which would have necessitated completely rebuilding this master tool. Therefore Mr. Myers stated that something else had to replace the rigid masters and this gave birth to the idea of the tooling dock as conceived by L. E. Bryant, vice-president of Consolidated-Vultee Aircraft Corporation. During the discussion Mr. Myers admitted that the tooling dock couldn't be depended upon with the use of unskilled labor but that the people using this instrument had to be highly trained to secure efficiency. He stressed an extremely important point and that was the cost of the tooling dock was one half of the master tool described and still could produce interchangeability in assembly jigs and the construction of a master that had to be shipped to vendors for any model ship. Therefore it was universal in its use and not designed primarily as a single-purpose tool. He also pointed out that engineering could use the tooling dock and accelerate the mock-up of any new ship which they had in mind. This would speed up the passing of information to the tooling division in the construction of assembly jigs in the event the customer placed an order.

A model of the tooling dock was exhibited; the audience seemed very enthusiastic regarding Mr. Myer's description of the construction and the use of this new instrument.

Conclusion

Commander Herman Garity of the United States Navy addressed the audience and stated that these meetings should be held monthly instead of once a year because of their importance to the country at this time. He also advocated interplant visits by the men holding nonadministrative positions rather than the "brass hats."

THOMAS A. WATSON

(Member A.S.M.E. and supervisor of tool engineering, University of California, chairman of the Program Committee and chairman of the Panel on Master Tooling.)

Contour Engineering Panel[2]

C. B. Carroll, chief project engineer of development engineering, Consolidated Vultee Aircraft Corporation, San Diego, California, opened the meeting with a discussion of the relationship of contour engineering to engineering and tool engineering. He stated that the engineering department is responsible for the dimensional integrity of the airplane and that the early practice of engineering was to release drawings to the tooling department for tooling. Since the majority of the drawings were made from small-scale layouts, the errors in scaling these layouts did not show up until the tooling department started the manufacture of templates and tools. It was obvious, therefore, that full-scale layouts had to be made in the engineering department.

Close relationship with the tooling department is of major importance. It is necessary that the engineering department work closely with tooling in the preparation of all templates. An assembly made with adequate production tooling is identical with every other assembly made with that tooling. Contour engineering is the foundation of assembly tooling. The contour engineer deals in the transformation of that which appears on the flat surface of a layout to the three dimensions with which the toolmaker must work. Interchangeability of parts, exact conformance to contour, and subassemblies fitting their next assemblies can only be achieved when the tooling department is furnished with correct master templates by the engineering department. The furnishing of this accurate information is the direct responsibility of the contour engineer.

[2] Compiled by J. C. Dillon, chairman of the session.

Harry L. Larson, project engineer, development-engineering department, Consolidated-Vultee Aircraft Corporation, San Diego, California, followed with a discussion of present-day usage of the so-called "cut-and-try" method of contour engineering. He pointed out that in many instances where the contours of small airfoils were being developed, the cut-and-try method was more expedient than many of the other methods that could be used and sufficiently accurate. Larger surfaces, however, should be developed either by mathematical methods or other more exact methods.

John J. Apalategui, project supervisor of lofting, Douglas Aircraft Company, discussed the important projective geometry theorems that are used in conic lofting. He gave several very lucid demonstrations of Pascal and Brianchon's theorems. He demonstrated a variety of useful applications.

L. J. Adams, department of mathematics, Santa Monica Junior College, Santa Monica, Calif., demonstrated how the equation of the conic is developed and how these equations can be used in lofting. He also showed a variety of useful applications.

Carter Hartley, staff engineer, North American Aviation, Inc., Inglewood, Calif., showed why master dimensional control is a function of contour engineering and then demonstrated how conic lofting aids in establishing that control.

J. A. Robin, group engineer of lofting, Lockheed Aircraft Corporation, Plant A, demonstrated the application of graphical scales to small airfoils. He indicated, however, that conic lofting was to be preferred where larger structures were involved.

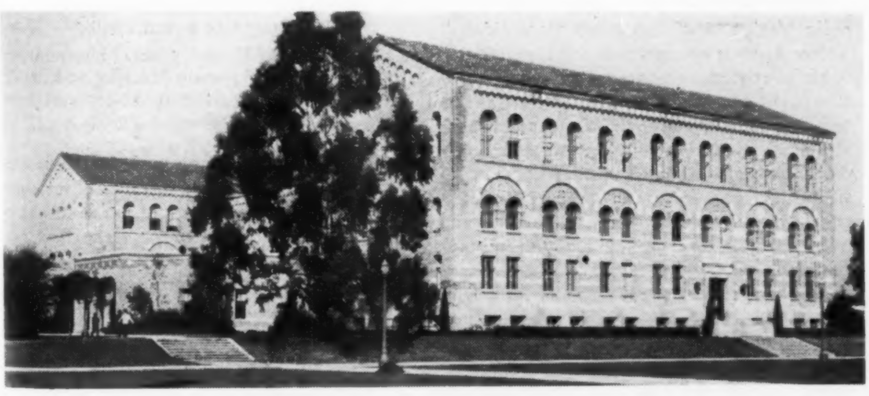
Dean Madsen, foreman of loft and template, Northrop Aircraft Company, Hawthorne, Calif., demonstrated several applications of the use of the graphical calculation in contour engineering. He also illustrated very clearly the difference between a fair and an unfair line. No one challenged his definition and differentiation.

Ward Pearce, contour engineer at Van Tuyl Engineering Company, Hollywood, Calif., discussed the development of contours by means of mathematical calculation. He advocated adoption of some of the marine methods of developing contours by the aircraft industry. He differentiated between the so-called natural curves and geometrical curves developed by mathematics.

Howard Thrasher, contour engineer at Consolidated-Vultee Aircraft Company, Downey, Calif., demonstrated very clearly a method of lofting that shows a picture of the part as the eye would see it, which makes possible visually correlating the lofted lines with the finished product.

The majority of the reports were very amply illustrated by means of slides. The audience participated enthusiastically in the discussions at the conclusion of each panel member's presentation.

(*Continued on following page*)



CHEMISTRY BUILDING AT UNIVERSITY OF CALIFORNIA, LOS ANGELES, WHERE AVIATION MEETING SESSIONS WERE HELD

Production Design Panel[3]

The high lights of the panel as judged from the interest demonstrated by the audience were mostly on the new processes and materials which will serve as tools for the airplane designer in his aim to release a production design which is most economical for the purpose intended.

A. H. Petersen of Lockheed Aircraft Corporation, Factory A, pointed out the necessity of properly breaking an airplane down into subassemblies for minimum expenditure of man-hours in assembly and installation and laid down a few of the principles a designer should follow in determining where his breaks should be.

E. W. Berger of Consolidated Vultee, by reviewing some case histories of assembly fastening in his corporation, accentuated the importance of the designer in providing for economy in our most fertile field, i.e., riveting. He pointed out that at present production rates, if one thousandth of one cent were saved on each rivet driven in the country per year two million dollars would be saved. One particularly interesting means of accomplishing such savings was his illustration of an automatic bucker which halved the personnel required on hand-driven rivets. New means of flushing rivets and of automatically driving them were demonstrated, and of special interest to the designer was his formula for location of co-ordinating holes for automatic riveting taking into account the tolerances of the rivet holes and the rivet diameters.

Fred Baum of Northrop, in true Northrop style of surprising the rest of the industry, discussed the proved practicability of percussion welding, which permits the welding of dissimilar metals to each other, and he showed samples of stainless-steel rod ends welded to magnesium rod, which withstood greater bending and tension stresses at the weld than could be withstood in the adjacent area. He exhibited flash welding of end fitting to heat-treated steel tubing of 6 in. diameter and $^{1}/_{2}$ in. wall and compared the cost saving over the previous welding on a cruciform-shaped part as approximately 16 to 1. He also exhibited an extrusion of 32 sq in. used for spar caps and pointed out that some extrusion in use at their plant was stepped at the end for increase in area required by incorporation of attachment fittings integral with the spar cap.

Ralph Rudd of North American convincingly stated that the tooling and methods which will be used in postwar will undoubtedly be the same as those employed under present high production rates, which are similar to those practices employed before the war. Subsequent discussion indicated that the North American Company would be in an exclusively better position in this respect than other companies.

The necessity for designers' intelligently choosing from the new high-strength alloys available, a material which will compete functionally yet be satisfactory for fabrication and assembly in the factory, was pointed out. Violent discussion followed Mr. Wheelon's (Douglas) talk regarding which alloy should be chosen and whether or not the merits of the alloy substantiated the extra handling and treating requirements in the factory.

The discussion by Mr. Papen of Lockheed Factory B demonstrated the importance of intelligently treating tolerances in the engineering department for the most economical fitting of parts and assemblies in the factory. His admonition to designers to guard against constraining parts to a greater degree than necessary were enlightening and his pointers regarding when take-up or adjustment should be applied in the design were excellently contrasted to the ruling on when take-up, if applied to the design, was only extra burden. The means of take-up and adjustment such as elongated hole, ferration, shim, and threaded fittings were brought out, but most interest technically resulted from his formula for tolerance between a female fitting and any combination of parts constituting the male fitting which it accommodates.

In general, the comments of those who attended revealed that the novel variety of subjects and processes brought to light were of exceptional interest to design engineers and manufacturing engineers.

Hydraulics[4]

The following is a brief summary of papers presented at the Hydraulic Session.

Designing the Hydraulic System of a Single-Engine, Single Place, Combat Airplane, by E. Kanarik and J. Jerome, hydraulic design staff engineers, Consolidated-Vultee Aircraft Corporation, Vultee Field, Downey, Calif.

Mr. Kanarik presented and explained the flow diagram for the hydraulic system selected for application to a particular plane. Since the airplane was a relatively small one the regular and emergency hydraulic circuits were relatively simple and could be easily followed by members of the audience.

Mr. Jerome presented a summary for the simplified methods and types of calculations used for the various hydraulic loads encountered in the design phase of development of the hydraulic system. Of particular interest were the calculating mechanisms presented for the calculation of hydraulic losses.

Hydraulics in Aircraft, by Ralph Middleton, hydraulics engineer, Aircraft Accessories Corporation, Burbank, Calif.

Mr. Middleton presented a description of several types of common airplane hydraulic control systems considering landing gear, flaps, and bomb-bay controls. He discussed the advantages and disadvantages of each system and presented a discussion of the advantages possible through remote electrical control of the hydraulic control valves.

The Alternating Current Trends in Aircraft Electrical Systems, by C. J. Bretwiesser, electrical-radio design staff engineer, Consolidated-Vultee Aircraft Corporation, San Diego, Calif.

Mr. Bretwiesser presented a clear demonstration of the advantages on an a-c electrical system over the conventional d-c system for large airplanes. He presented experimental and predicted values as examples of points under consideration. One feature of the proposed electrical system is the combined mechanical and hydraulic gear for coupling used for constant generator speed when driven by a standard motor at speeds between 700 and 2700 rpm.

High-Speed Milling

Hans Ernst presented a paper on recent research in high-speed milling. In connection with his paper he showed some high-speed motion pictures (3000 frames per sec) which he had recently taken, and which showed very nicely, at considerable magnification, the effect of both negative and positive over a range of

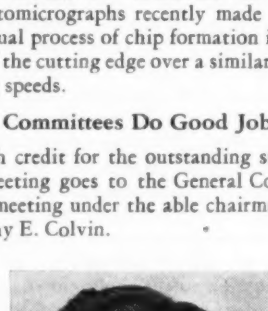
HANS ERNST

(Member A.S.M.E. and research director, Cincinnati Milling Machine Co., presented paper on "Recent High-Speed Milling Research," with slow-motion movies of chip action, shown for the first time.)

cutting speeds from about 100 to 800 ft per min. This was the first time pictures of this nature were shown. He also showed a number of photomicrographs recently made showing the actual process of chip formation in the region of the cutting edge over a similar range of cutting speeds.

Committees Do Good Jobs

Much credit for the outstanding success of this meeting goes to the General Committee of the meeting under the able chairmanship of Timothy E. Colvin.



TIMOTHY E. COLVIN

(Member A.S.M.E. and general chairman of the Los Angeles Aviation Meeting and executive vice-president Aircraft Accessories Corporation.)

The comprehensiveness and well-balanced program, particularly the three panel sessions, were due in no small measure to the efforts of T. A. Watson, the chairman of the Program Committee.

The University of California and the University's designated representative, Prof. Wendel E. Mason, made every effort possible to assist in the successful operation of the meeting. Ideal lecture halls and perfect equipment were provided for all sessions. Professor Mason can be given much of the credit for the perfectly smooth operation of the meeting.

[3] Compiled by Harold Harrison, chairman of the session.

[4] Compiled by R. G. Folsom, chairman of the session. Mem. A.S.M.E.

17th National Oil and Gas Power Conference at Tulsa Highly Successful

Largest Registration Yet Recorded

MORE than 350 engineers, the largest registration yet recorded, attended the 17th National Oil and Gas Power Conference held at Tulsa, May 8 to 10. They were rewarded by an exceptionally valuable technical program, and the hospitality of Tulsa engineers made the meeting pleasant as well as profitable.

"All-Engineers" Luncheon Opened Conference

In co-operation with the Engineers Club of Tulsa, an "All-Engineers" luncheon opened the Conference. Close to 300 visitors and local engineers heard words of welcome from Tulsa's newly elected mayor, Olney Flynn, and a short talk by A. E. Ballin, formerly president of McIntosh & Seymour Co. Taking as his subject, "The Early Days of the Diesel Locomotive," Mr. Ballin drew on his intimate connection with this development for the many little-known facts that highlighted his interesting discussion.

Demonstrating the technical interest aroused by the gas turbine, first new prime mover in 50 years, a capacity crowd of approximately 250 attended the first technical session, which was devoted to that subject. Papers by Messrs. Tucker and Salisbury, published in June MECHANICAL ENGINEERING, stimulated active and extended discussion.

B. P. Sibole Toastmaster at Banquet

Under the genial toastmastership of B. P. Sibole, president of Stanolind Pipe Line Co., the banquet held Monday evening proved a high point of good fellowship. Captain Lisle F. Small, Bureau of Ships, U.S.N., speaker of the evening, traced the growth of the internal-combustion engine in naval service, pointing out that just recently the total Diesel horsepower in the U.S. Navy passed the total steam horsepower. Looking to the future, he outlined the trend by which desired higher specific output may be obtained and ventured a prediction that the ultimate internal-combustion propulsion unit might be a combination of the free-piston Diesel compressor and the gas turbine, with the Diesel unit supplying only exhaust gas under pressure to the turbine, which generates all the useful energy.

After a morning session on power plants, the group divided into several parties for an afternoon of inspection trips. A small group visited the school operated by Sparton Aircraft and another larger party went to the maintenance shops of the Stanolind Pipe Line Co. Still a third group saw some unusual shell-forging operations at the Hinderliter Tool Co. and then went on to the Stanolind shops.

"The Shape of Wings to Come"

Again in co-operation with the Engineers Club of Tulsa, an evening session to which all engineers were invited was held on Tuesday evening. R. A. Miller, of American Air Lines, told of the complex maintenance routine that keeps the flagships of the air on schedule and Geoffrey Morgan, of Douglas Aircraft, spoke of "The Shape of Wings to Come," an extremely interesting preview of commercial aviation's future.

The final day of the Conference was devoted to morning and afternoon technical sessions on engine controls and governing. For about 25 engineers who were specially interested, a visit to the world's largest gas-engine plant, at Jones Mills Works of the Aluminum Co. of America, near Hot Springs, Ark., proved an outstanding added attraction.

Credit Where Credit Is Due

Credit for much of the success of the meeting goes to the officers and members of the Mid-Continent Section, A.S.M.E., and to the wholehearted co-operation of the Engineers Club of Tulsa.

Names of officers of the Mid-Continent Section, of the Oil and Gas Power Division, and of the National Conference Committee follows:

Mid-Continent Section

D. A. Cant, *chairman*
R. A. Colgin, *vice-chairman*
C. H. Stevens, *vice-chairman*
J. H. Keyes, *secretary*
Nathan Janco, *treasurer*

Roscoe Ayers	R. F. Hurt
D. O. Barrett	D. K. Hutchcraft
W. L. Ducker, Jr.	A. J. Kerr
C. O. Glasgow	H. T. Sears

W. S. Sherman

Oil and Gas Power Division

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TECHNICAL PROGRAM

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C. E. Beck	P. B. Jackson
G. J. Dashefsky	R. T. Sawyer

National Conference Committee

D. A. Cant, *associated societies*
C. O. Glasgow, *registration*
Orval Lewis, *meetings and entertainment*
G. W. Butrovich, *inspection trips*
J. B. Harshman, *inspection trips*
Dallas Deem, *inspection trips*
C. H. Stevens, *transportation*
A. F. Campbell, *exhibits*
F. C. Taylor, *publicity*

King's "Unwritten Laws of Engineering" Available as Reprints

REPRINTS in one pamphlet of the three parts of W. J. King's paper on "The Unwritten Laws of Engineering" running in the May, June, and July, 1944, issues of MECHANICAL ENGINEERING will be available for sale early in July.

These reprints will cost twenty cents for individual copies (please send stamps). Quotations will be given for reprints in quantities by addressing your inquiry to the publication sales department, A.S.M.E. headquarters.

A.S.T.M. Standards on Refractory Materials

THE latest Manual of A.S.T.M. Standards on Refractory Materials with other pertinent information and data is the fifth sponsored by A.S.T.M. Committee C-8 on Refractories. It includes new standards for air setting refractory mortars, fireclay plastic refractories both for boiler and incinerator services, methods of test for measuring the shrinkage, spalling, and workability index of fireclay plastic refractories, and a method for measuring the thermal conductivity of insulating fire brick.

Seven specifications on refractories for various types of service are given in the book. There are two classifications of materials and the remaining 16 standards give widely used methods of testing. An important part of the book is a group of industrial surveys which are a most important contribution to the literature in this field. These surveys describe the operations carried out in the furnaces, the types of refractories used in them, and outline the conditions which affect the life of the refractories.

This publication may be obtained from A.S.T.M. headquarters, Philadelphia, Pa.

Patents on Vibration Dampers and Mountings

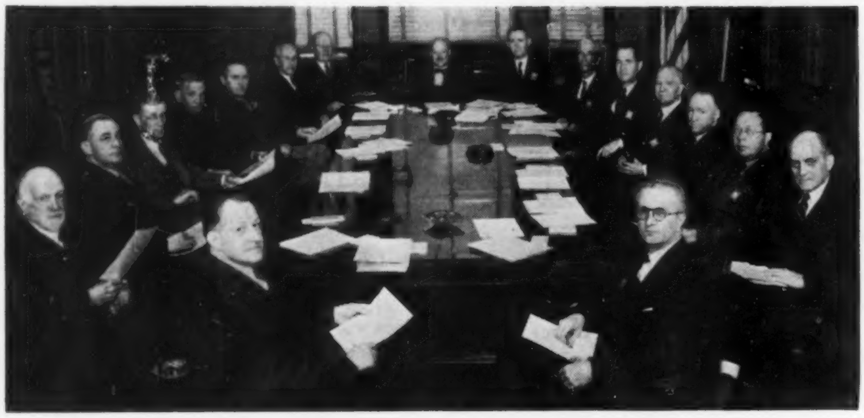
THE Secretary of The American Society of Mechanical Engineers has received from the Office of the Alien Property Custodian a list of 64 patents of former enemy ownership relating to vibration dampers and mountings.

Members interested in these patents should communicate with one of the Patent Administration Division's offices in the Field Building; Chicago, Ill.; 120 Broadway, New York, N. Y.; 17 Court Street, Boston, Mass.; and 310 Guardian Building, Portland, Ore.

Proceedings of Annual Water Conference

PROCEEDINGS of the fourth Annual Water Conference of the Engineers' Society of Western Pennsylvania are now available at $3.15 a copy and may be obtained direct from the headquarters of that Society at the William Penn Hotel in Pittsburgh, Pa.

The fifth Annual Water Conference is scheduled for Oct. 30-31, 1944, in Pittsburgh.



NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS MEETING, WASHINGTON, D. C. APRIL 20, 1944

(*Front two:* William Littlewood, vice-president, engineering, American Airlines, Jun. A.S.M.E.; Dr. Theodore P. Wright, director, Aircraft Resources Control Office, Aircraft Production Board. *Left to right:* Dr. William F. Durand, professor emeritus of mechanical engineering, Stanford University, Calif., past-president and honorary member, A.S.M.E.; Maj. Gen. Oliver P. Echols, U.S.A., assistant chief of air staff, matériel, maintenance and distribution, Army Air Forces; Dr. Vannevar Bush, director, Office of Scientific Research and Development; Vice-Admiral John S. McCain, U.S.N., deputy chief of naval operations (Air); Maj. Gen. Barney M. Giles, U.S.A., chief of air staff, representing Gen. Henry H. Arnold, Commanding General, A.A.F.; Dr. Orville Wright, honorary member, A.S.M.E.; Dr. George W. Lewis, director of aeronautical research, N.A.C.A; Dr. Jerome C. Hunsaker, chairman, N.A.C.A., past vice-president, A.S.M.E.; John F. Victory, secretary, N.A.C.A.; Dr. Charles G. Abbot, secretary, Smithsonian Institution; Dr. Edward Warner, vice-chairman, Civil Aeronautics Board, member A.S.M.E.; Dr. Lyman J. Briggs, director, National Bureau of Standards; Rear Admiral Ernest M. Pace, U.S.N., Special Assistant (Material), Bureau of Aeronautics; Hon. William A. M. Burden, assistant secretary of Commerce; Dr. Francis W. Reichelderfer, chief, U. S. Weather Bureau.)

N.A.C.A. Holds Meeting in Washington, April 20

AT the regular meeting of the National Advisory Committee for Aeronautics in Washington on April 20, military leaders of the Army and Navy air organizations discussed with their civilian scientific colleagues on the N.A.C.A. possible means to improve the military effectiveness of combat airplanes. Dr. Theodore P. Wright of the War Production Board, a member of the Committee who had just returned from a visit to England, reported the results of his observations of American airplanes in service in the European Theater.

Among the problems discussed were jet propulsion, means further to reduce the drag of airplanes, and the military advantages of high factors of structural strength even at the expense of weight.

Papers on "Furnace Performance Factors" "Graphitization of Steel Piping" Published in Limited Edition

PAPERS on "Furnace Performance Factors" and "Graphitization of Steel Piping presented at the 1943 Annual Meeting of the A.S.M.E. have been published for reference purposes in a limited edition for binding with the 1944 volume of the Transactions of the Society. There are, however, a small number of both of these pamphlets for sale at one dollar and at fifty cents, respectively.

This procedure was followed at the request of the Publications Committee of the Society who felt that the acute shortage of paper warranted such action when articles are of immediate interest to relatively few.

Diesel and Automotive-Diesel Performance and Cost Data for 1942

THE A.S.M.E. Subcommittee on Oil Engine Power Cost has recently issued the results of its survey of Diesel and automotive-Diesel performance and cost data for the year 1942. The Report on Low-Speed Stationary Generating Plants follows the lines developed over the last several years, with cost and performance data presented in tabular form and charts showing lubricating-oil and fuel economy. Data were obtained from 160 oil-engine generating plants, containing 467 engines which generated 437,012,282 net kwhr. Approximately 100 of the plants that submitted information were making their sixth report, 61 plants were reporting for their tenth year, and eight plants for the fourteenth consecutive year.

The data resulting from the fourth annual survey of Performance and Operating Costs of Diesel Engines Used in Automotive Equipment has grown to such an extent as to warrant its publication as a separate report. The tabulation of data collected for 1942 contains detailed information received from fourteen owners and operators of Diesel-powered buses and trucks and covers 1057 vehicles. Presented in the 1942 Report is such significant information as: type of vehicles, type of service, number of engine road failures and their causes, costs per mile or hour for fuel, lubrication, fuel and lubricating-oil taxes, and engine maintenance.

Reports are available from the A.S.M.E. Publication-Sales Department, 29 West 39th Street, New York 18, N. Y. at $1.25 and 25 cents each respectively.

Synthetic-Rubber Glossary Now Available in Printed Form

TO meet unexpected demands for its glossary giving pronunciations and meanings of synthetic-rubber terms, Hycar Chemical Company, largest private producer of butadiene-type synthetic rubber, has had this information printed as a $5^1/_2 \times 8^1/_2$-inch, 8-page pamphlet.

Copies of this booklet entitled, "Chemical Names and Terms Frequently Encountered in the Synthetic Rubber Industry," may be obtained by writing to the Hycar Chemical Company, 335 South Main Street, Akron, Ohio.

National Roster Wants Professional, Scientific Personnel

THE National Roster of Scientific and Specialized Personnel in the War Manpower Commission is the agency of the Federal Government which, since 1940, has served as a central registry for persons possessing professional or scientific qualifications.

All professionally qualified young engineers, chemists, physicists, geologists, mathematicians, etc., should be registered with the National Roster.

In the light of recent Selective Service directives which will result in the induction of many thousands of professionally and scientifically qualified young men under the age of 26, it is important that these particular individuals who will enter the armed forces immediately notify the Roster of the branch of the armed forces they are entering, the date and place of their induction, and, after induction, their serial number.

It is important, therefore, that persons possessing professional or scientific qualifications register with the Roster and advise it immediately concerning any change in their status. Communications should be addressed to the National Roster of Scientific and Specialized Personnel, 1006 U Street, N. W., Washington 25, D. C.

If It's Late

THE mailing date of MECHANICAL ENGINEERING is the twenty-sixth day of the month prior to the month of issue. With very few exceptions the editors and printers have met this date for many years. Owing to the heavy load both on printing and postal services, copies of the magazine are sometimes delayed in delivery. The editors do not wish to evade responsibility by shifting it to other shoulders, but delay is usually not their fault.

War Department Thanks Engineering Societies Library

THE following letter is indicative of the kind of assistance the Engineering Societies Library is giving to our military forces.

WAR DEPARTMENT

OFFICE OF THE CHIEF OF ENGINEERS

WASHINGTON

Dr. H. W. Craver
Engineering Societies Library
29 West 39th Street,
New York, N. Y.

Dear Dr. Craver:

The month of May marks the second year of our association and I wish to take this opportunity to thank you and the Library for your splendid co-operation.

The assistance of the Engineering Societies Library has been the chief reason why our Engineer Research Office in New York City has been able to provide this office, the planning staffs in Washington, and the theater commanders with urgently needed information on the details of engineering facilities in enemy-occupied countries. Captain Vogler says that you have gone out of your way many times in order to help him and that it is doubtful that his office could have accomplished its work without your assistance.

Undoubtedly, there were many times during which your patience was sorely tried by our requests for voluminous amounts of material, so it may be a compensating factor to know that the processed information has proved very helpful to those concerned with both planning and operations.

For the Chief of Engineers:

Very truly yours, H. B. LOPER
Colonel, Corps of Engineers
Chief, Military Intelligence Division

Gantt Medal to Gilbreths

THE Gantt Medal Board of Award has announced that the Gantt Medal for 1944 has been unanimously awarded to Lillian M. Gilbreth and Frank B. Gilbreth (posthumously) "in recognition of their pioneer work in management, their development of the principles and technics of motion study, their application of those technics in industry, agriculture, and the home, and their work in spreading that knowledge through courses of training and classes at universities."

Dr. Lillian M. Gilbreth, member A.S.M.E., is president of Gilbreth, Inc. Mr. Gilbreth, whose death occurred in 1924, was also a member of A.S.M.E. Mr. Gilbreth was active in committee work and in the Management Division of the Society, and Dr. Gilbreth has continued to give constant service to these interests.

Research Council Formed at Rutgers

RUTGERS University has announced the creation of a Research Council to promote research in all departments of the university. A survey is now being made of personnel and facilities to determine where new funds for research can best be invested. The Council consists of nine members from various colleges and departments, including Dr. P. A. van der Meulen, professor of chemistry, and James L. Potter, professor of electrical engineering. Dr. William H. Cole, professor of physiology and biochemistry at Rutgers since 1928, has been appointed director of the Council. He will serve in a staff relationship to deans, department heads, and faculty members concerning research programs, and will represent the university in developing reciprocal arrangements with governmental, industrial, business, and professional institutions outside of the university.

Four projects in chemistry and three in engineering of immediate value to the war effort are now under way and it is expected that others will be started within the next few months.

A special research fund has been placed at the disposal of the Council and applications for grants for next year are now being considered. Emphasis will be placed upon co-operative research between departments and between outside organizations and university departments.

A.S.M.E. War Production Committee Visits Aberdeen Proving Ground on May 24

WITH the approval of Major General Levin H. Campbell, Jr., Chief of Ordnance, U.S.A., the War Production Committee of the A.S.M.E. at the invitation of Major General G. M. Barnes, Chief, Technical Division, Office of Chief of Ordnance, visited Aberdeen Proving Ground in Maryland on Wednesday May 24, 1944, and enjoyed an eventful day.

There the group saw an exhibition of some 4000 tons of captured enemy weapons and ammunition which have been classified and studied. They also witnessed a program of current firings of articles of ordnance adopted as standard for issue to the Service or under development for submission to the Service for field test. And finally they were shown the maneuvering tests of various types of automotive vehicle, both standard and under development.

General Barnes who directs Ordnance research and development, on April 4 in his paper before The American Society of Mechanical Engineers at the Spring Meeting in Birmingham, Ala., said "We now possess practically every known type of enemy weapon," adding, "We have at the proving ground more than 4000 tons of these weapons and ammunition of all types and descriptions which have been sorted out and classified and studied. With firsthand knowledge of enemy weapons, we have been able to keep well ahead of German and Japanese weapons." General Barnes's paper, "Keying Research to Battle," was published as the leading article in the June, 1944, issue of MECHANICAL ENGINEERING.

Institution of Mechanical Engineers and A.S.M.E. Interchange Honors and Pledge Co-Operation

A GATHERING of great significance to the mechanical engineers of Great Britain and the United States was held on June 5, 1944, at the British Embassy in Washington, D. C. On that day, at the invitation of Lord Halifax, British Ambassador, two-score of leading mechanical engineers, representing The Institution of Mechanical Engineers of Great Britain and The American Society of Mechanical Engineers, met for the interchange of honors and a pledge of continued co-operation.

Following a brief, informal reception on the sunlit terrace of the Embassy, in a pleasant temperature unusual for Washington in June, the Ambassador gathered his guests into the Great Hall for the brief ceremonies.

Associated Press Photo

BRISTISH AMBASSADOR LORD HALIFAX (CENTER), ON BEHALF OF THE BRITISH INSTITUTION OF MECHANICAL ENGINEERS, CONFERS HONORARY MEMBERSHIP IN THE INSTITUTION TO DR HARVEY N. DAVIS, (SECOND FROM RIGHT), PAST-PRESIDENT, A.S.M.E., AT THE BRITISH EMBASSY, WASHINGTON, D. C., JUNE 5, 1944

(At the ceremony are (left to right): William L. Batt, Past-President, A.S.M.E.; Robert M. Gates, President, A.S.M.E.; Lord Halifax; Dr. Davis; and A. C. Hartley, member of the council of the British Institution.)

Painting of James Watt Presented

As the first event the Ambassador, on behalf of The Institution of Mechanical Engineers, presented a painting of James Watt to The American Society of Mechanical Engineers. The Ambassador explained that the picture was a copy of the painting by de Breda made during the life of Watt which, after passing through many hands, came into possession of the Institution. That body, preparing for the British-American Engineering Congress to be held in New York September, 1939, had had a copy made for the A.S.M.E., formal presentation of which had been delayed because of the abandonment of the conference due to the war. Lord Halifax paid tribute to the co-operation during the war between the engineering profession of the two nations. President Gates of the Society, accepting the picture, paid tribute to the heritage left to the mechanical engineers by Watt and his distinguished British followers and stated that the presence of the picture on the walls of the Society served as a reminder of the common interests of the profession of both nations and a pledge of continued co-operation.

The Ambassador then presented a certificate of honorary membership, awarded by the Institution to Orville Wright, to President Gates for conveyance to Mr. Wright. The Ambassador paid high tribute to Mr. Wright's outstanding achievements in pioneering in aviation science.

Mr. A. C. Hartley, member of the Council of The Institution of Mechanical Engineers, then presented its honorary membership certificate to Dr. Harvey N. Davis, past-president of the Society, in recognition of his outstanding leadership in steam research and in advancing production engineering during the present emergency.

Mr. Batt Closes Ceremonies

The ceremonies were closed by William L. Batt, past-president of the Society, who expressed the appreciation of those present for the courtesy and hospitality of the Embassy. He stressed the importance of continued understanding between the engineers of the two English-speaking nations.

Following tea on the terrace the party adjourned for dinner at the Hotel Statler in Washington at which brief remarks were made by President Gates, Mr. Hartley, Dr. Davis, Professor A. G. Christie, William L. Batt, and Secretary C. E. Davies. Those present at the dinner were: Representing The Institution of Mechanical Engineers, Brigadier C. L. Lindeman, A. C. Hartley, Col. Smith Rollo, Lieut. Col. O. G. Trevithick, Maj. F. J. Edwards, Wing Commander A. C. T. Isaac, F. Dosser, A. F. McCulloch, C. M. Smith, E. W. Edwards, W. E. Taylor, A. E. Faro, John F. Firth-Hand, and L. C. Scarborough.

Representing the A.S.M.E. were: R. M. Gates, Harvey N. Davis, A. G. Christie, W. L. Batt, D. W. R. Morgan, W. J. Wohlenberg, Wm. G. Christy, Maj. Gen. Wm. H. Tschappat, Wm. H. Kenerson, H. H. Snelling, R. F. Gagg, J. W. Roe, Paul B. Eaton, C. E. Miller, and Col. C. E. Davies.

Ennis and Timoshenko Honored by Franklin Institute

AT the annual Medal Day ceremonies of The Franklin Institute of Philadelphia, on April 19, Joseph Burroughs Ennis, member A.S.M.E., senior vice-president of the American Locomotive Company, New York, N. Y., received the George R. Henderson medal for work in locomotive engineering and design.

Prof. Stephen P. Timoshenko, fellow A.S.M.E., of Stanford University, was awarded the Louis E. Levy medal for a paper entitled, "The Theory of Suspension Bridges," published in the journal of the Institute.

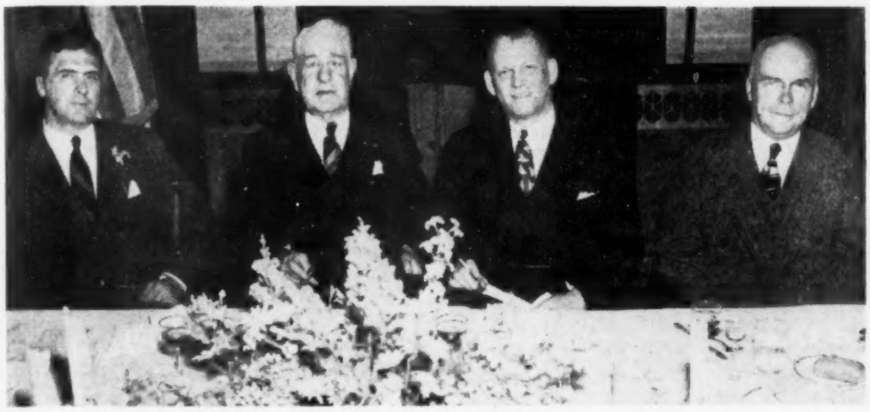
M. H. Kotzebue Receives Hanlon Award

ON April 13 during the convention of the Natural Gasoline Association of America, M. H. Kotzebue, member A.S.M.E. and president of the Gasoline Plant Construction Company of Houston, was presented the Hanlon award for "his foresight and practical engineering judgment in the design and construction of natural-gasoline and cycling plants which has made possible savings in production costs and the conservation of natural resources on a scale hitherto impossible by other means.

Mr. Kotzebue is the eighth recipient of this award—the highest honor accorded within the natural-gasoline field.

Ship Named for Former A.S.M.E. Member

ON April 14, at Savannah, Ga., a Liberty ship was christened in honor of William D. Hoxie, former A.S.M.E. member, who designed the marine water-tube boiler of the Babcock and Wilcox Company. Mr. Hoxie, who died in 1925, was granted a patent for his design in 1897. This boiler, improved and modified to burn oil fuel, was widely used in the Emergency Fleet vessels of World War I and is essentially the same design used in the Liberty ships of the present war.



AT THE DINNER IN HONOR OF W. R. WEBSTER

(*Left to right:* Gibson Carey, Jr., president of Yale and Towne Manufacturing Co., and past-president of the Chamber of Commerce of the United States; William R. Webster; Colonel Herman W. Steinkraus, president of Bridgeport Brass Co. and toastmaster at dinner, and Robert M. Gates, President, A.S.M.E.)

Testimonial Dinner Given in Honor of W. R. Webster by Bridgeport Section

President R. M. Gates Presents Pin Commemorating Bridgeport Brass Company Official's Fifty Years in the Society

HIGH praise for services and leadership contributed to the field of mechanical engineering and the community in general was bestowed upon William R. Webster, chairman of the board of Bridgeport Brass Company, at a testimonial dinner in the Algonquin Club, Bridgeport, Conn., on May 16. Attended by many friends and colleagues of the guest of honor, the testimonial was sponsored by the Bridgeport Section of The American Society of Mechanical Engineers in observance of Mr. Webster's fifty years' membership in the Society.

R. M. Gates, president of the Society, presented Mr. Webster with a 50-year pin, and, in accepting the award, Mr. Webster said the pin came to him primarily for the passing of the years and that it was a high honor to receive it from the president of such a distinguished organization.

In reviewing his 50 years of work in the engineering field, Mr. Webster remarked that during that space of time a greater advancement in material things has taken place than ever before in a similar period in our history. He added, however, that he hoped that the following 50 years would show even a greater advancement.

W. Gibson Carey, president of the Yale & Towne Manufacturing Company, Stamford, Conn., and a former president of the United States Chamber of Commerce, complimented Mr. Webster on his remarkable foresight and his contributions to the general welfare. Emphasizing the principles of free enterprise and freedon of mind and body, Mr. Carey said that Congress must regain some of its powers if these aims are to be perpetuated.

Other speakers included Mayor Jasper McLevy; George E. Crawford, president of the Bridgeport Chamber of Commerce; George S. Hawley, president of the Bridgeport Gas Light Company, and Arthur Keating, president of the Bridgeport Engineering Institute. Col. Herman W. Steinkraus, president of the Bridgeport Brass Company, was toastmaster, and Col. J. D. Skinner was chairman of the arrangements committee. Guests included Lieut. Comdr. G. S. Barker, Capt. John Sandham, and leading industrialists.

Anthracite - Lehigh Section Holds Dinner Meeting

The Anthracite-Lehigh Valley Section held a dinner meeting on March 24. The guest speaker of the evening was R. E. Brown, works manager, Allentown Division of Consolidated Vultee Aircraft Corporation, who spoke on the subject of "Scientific Methods that Characterize Aeronautical Engineering." At a brief business meeting held earlier in the evening, the Executive Committee unanimously approved the election of new officers for the year beginning July 1, 1944, as follows: Chairman C. H. Folmsbee; vice-chairmen, James A. Gish, Jr., Walter Tallgren, W. G. McLean; secretary-treasurer, J. W. Bliss; managers (2 years), S. I. Hammond, W. E. Anderson, L. E. Mylting, and K. W. Bloom; assistant managers (2 years), R. W. Morgan, E. W. Nelson, C. R. Dieckman, and C. W. Bell.

Baltimore Section Learns of "Enemy Matériel" From Colonel Jarrett

"Enemy Matériel" was the subject discussed by Lieut. Col. G. B. Jarrett, guest speaker at a well-attended meeting of the Baltimore Section on April 24. The speaker was well qualified to present this topic, having studied ordnance matériel extensively since World War I. While in the El Alamien Sector of the African Theater of Operations in the present conflict, he inspected captured German equipment. He presented numerous snapshots of this equipment to illustrate comparisons between American and foreign matériel.

Mystic Power Plant Inspected by Boston Section

Two hundred members and guests of the Boston Section went on an inspection tour of the Mystic Plant of the Boston Edison Company, on the afternoon of May 18. In the evening, W. W. Edson, G. A. Orrok, Jr., and H. E. Stickle presented a paper on the Mystic Plant, explaining its electrical design, mechanical design, and operations of the plant.

Die-Casting Usages Related at Cleveland

On May 11, members of the Cleveland Section heard Adrian Weiss, treasurer of the Superior Die Casting Company, speak on the subject of "Die Casting," which briefly covered characteristics and uses of die castings of different compositions. A film of the same title, lent through the courtesy of the New Jersey Zinc Company, was then enjoyed by the 35 members and guests in attendance.

Aviation Discussed at Joint Columbus Meeting

A. T. Colwell spoke on the subject of "Wings—Today and Tomorrow," at the April 28 meeting of the Columbus Section, held jointly with the members of the Southern Ohio Section of the S.A.E. Mr. Colwell pointed out that in aviation there is a constant need for increased horsepower, and then traced the development of power plants. He also explained why long nonstop flights are remote, due to the large fuel loads entailed, which would make such flights unprofitable.

Dr. C. W. Williams Speaks at Louisville Section

The theory of electroprecipitation of solids from gases was discussed at the April 27 meeting of the Louisville Section, by Dr. C. W. Williams of the American Air Filter Company.

A.S.M.E. Calendar

of Coming Meeting

October, 2–4, 1944
A.S.M.E. Fall Meeting
Cincinnati, Ohio

October 30-31, 1944
Joint Meeting of A.S.M.E. Fuels and A.I.M.E. Coal Divisions, Charleston, West Va.

November 27–December 1, 1944
A.S.M.E. Annual Meeting
New York, N. Y.

(For coming meetings of other organizations see page 40 of the advertising section of this issue)

Dr. Williams explained the recent developments in this field and described its modern applications to air filtering, with indications of future trends.

Postcollegiate Education Is Topic at Milwaukee

Industry's responsibility for postcollegiate education was stressed by Dr. A. R. Stevenson, Jr., at the April 19 meeting of the Milwaukee Section. Dr. Stevenson, who is staff assistant to the vice-president in charge of engineering in the General Electric Company, Schenectady, N. Y., and responsible for postcollegiate education within his company, outlined in detail how engineering would win the peace, education's present trends, educational responsibility, training for leadership, and the like.

This Section met again on May 10, when recent developments in plastics were brought out by J. O. Reinecke of Barnes & Reinecke, Chicago, Ill. Mr. Reinecke reviewed many of these new developments, such as high-frequency heating, jet molding, low-pressure molding, and others, and emphasized their application to engineering design. Preceding the talk, two short movies, "The Fourth Kingdom" and "Curves of Color," were shown.

Pumping History Reviewed at Raleigh Section

Prof. R. W. Morton lectured on the "History of Pumping," at the May 3 meeting of the Raleigh Section. This was a brief presentation on early types of pumping equipment and their modern prototypes, with illustrations visualizing the progress of pumping up to the year 1900.

Future Chemical Plans Outlined at St. Louis

A decrease in the cost of materials will result from increased production in the postwar chemical industry, F. J. Curtis told members of the St. Louis Section at a meeting on April 28. Mr. Curtis said that among the important developments were products being produced by the synthetic-rubber manufacturers which would make the materials economically useful in many fields where formerly they were unavailable.

Subject at Rochester Is "Food Dehydration"

A brief review of the principle involved in "Food Dehydration" was presented by Richard Vidale of Douglas McBean, consulting engineer, Rochester, N. Y., at the May 11 meeting of the Rochester Section. Mr. Vidale stressed the danger points of failure and gave a detailed explanation of the methods used in food preparation.

Differential Analyzer Explained at West Va. Section

Addressing the West Virginia Section on April 25, E. S. Lee, head of the General Engineering Laboratory, General Electric Company, Schenectady, N. Y., chose as his subject, "What's New in Science and Engineering." Among the interesting advances and developments in instruments and regulators Mr. Lee described were the differential analyzer, developed and built for wartime research problems, special oscillographs, and numerous similar devices. Approximately 150 members and guests were in attendance.

Past-Chairmen's Meeting at San Francisco

The regular April Meeting of the San Francisco Section on April 27 was designated past-chairmen's meeting with the following nine past chairmen in attendance: A. J. Dickie, 1926–1927; William Moody, 1932–1933; H. B. Langille, 1934–1935; F. W. Collins, 1935–1936; O. B. Lyman, 1936–1937; G. L. Sullivan, 1937–1938; George H. Raitt, 1939–1940; V. F. Estcourt, 1940–1941, and G. N. Somerville, 1942–1943. Expressions of regret at being unable to attend the meeting were received from Warren H. McBryde, Robert Sibley, Dennistoun Wood, Dr. W. F. Durand, W. W. Hanscom, and Harold T. Avery. Every one of the attending past-chairmen spoke at the meeting and their remarks were received by an appreciative audience. The membership expressed a desire that once a year a particular meeting should be designated as past-chairmen's meeting.

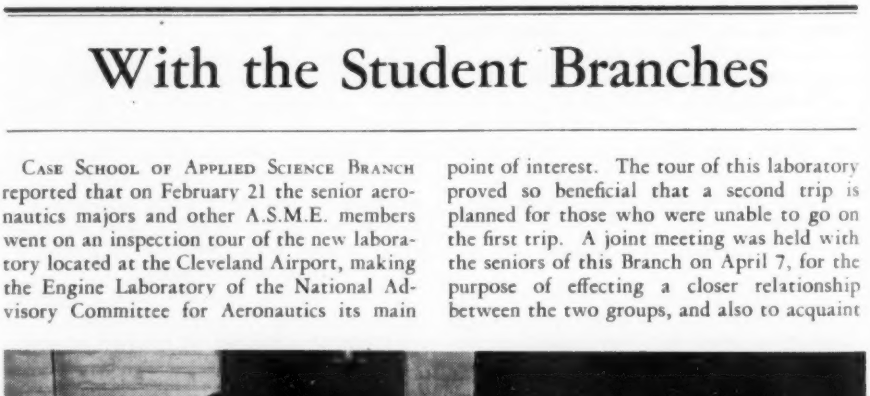
This section also announced that arrangements have been made to hold the A.S.M.E. Semi-Annual Meeting in 1946, in San Francisco provided, however, that by that time the war is over and conditions warrant it. The meeting is to be held in conjunction with the "Postwar Congress of Trade, Industry, Engineering, and Finance for the Development of the Lands of the Pacific Ocean." F. T. Letchfield of the Wells Fargo Bank & Union Trust Company has accepted the general chairmanship for this meeting.

Western Massachusetts Holds 25th Annual Ladies' Night and Dinner Meeting

The Engineering Society of the Western Massachusetts Section held its 25th Annual Ladies' Night and Dinner Meeting on May 16, with 223 members and guests in attendance. Following the dinner, George Williamson, one of the past presidents, gave a brief historical review, after which Col. Warren J. Clear of the War Department, Washington, D. C., spoke on "The Jap, at Home, on Corregidor-Bataan, and Elsewhere." Another guest speaker was Rear Admiral Wat Tyler Cluverius, president of the Worcester Polytechnic Institute, Worcester, Mass., who chose as his topic, "The Job: Today and Tomorrow."

With the Student Branches

CASE SCHOOL OF APPLIED SCIENCE BRANCH reported that on February 21 the senior aeronautics majors and other A.S.M.E. members went on an inspection tour of the new laboratory located at the Cleveland Airport, making the Engine Laboratory of the National Advisory Committee for Aeronautics its main point of interest. The tour of this laboratory proved so beneficial that a second trip is planned for those who were unable to go on the first trip. A joint meeting was held with the seniors of this Branch on April 7, for the purpose of effecting a closer relationship between the two groups, and also to acquaint



STUDENT EXPLAINING APPARATUS IN SAND-TESTING LABORATORY, CASE SCHOOL OF APPLIED SCIENCE

(Joint Meeting of A.S.M.E. Student Branch with senior aeronautics majors.)

UNIVERSITY OF KANSAS BRANCH, TAKEN ON THE STEPS OF MARVIN HALL, THE ENGINE BUILDING

(Those in the picture are: *Front row, left to right:* Elden Leuhring, Maurice Updegrove, James Walker, Prof. Ralph Tate, Clarke Hargiss, Robert Maurer, Prof. Wray Fogwell, Prof. Earl Hay, Prof. E. E. Ambrosius, and Joe Wilson. *Second row, left to right:* R. J. Riedel (not yet a member), Walter Siegerist, Charles Smith, Henry Moon (not yet a member), John Hillard, Kenneth Mattley (not yet a member), Clifford Bates, Melvin Hicks, and Aubrey Gibson. *Third row, left to right:* John Lednicky (not yet a member), Allen Talbot, Morris Beck, Vernon Selde, Charles Langdon, P. W. Godfrey, John Williams, and Bruce Benedictson. Picture taken for the *Jayhawker.*)

the senior members with the research work being carried out in the mechanical-engineering building.

A belated report of the COLORADO BRANCH disclosed that Mr. Throne, from Public Service Company, was the guest speaker at its meeting on December 8. Mr. Throne gave a talk on the installation of the steam turbine at the Valmont Plant. On May 10, this Branch held a brief business meeting, after which Prof. W. L. Hull of the mechanical-engineering department, gave an illustrated account of "Foreign Aircraft." Features of engine and body construction, supercharging, cooling, visibility, and the like, of the improved German, English, and Japanese airplanes were outlined in detail. A question period followed Professor Hull's comments.

One of the largest representations of V-12s to appear at a COLUMBIA BRANCH meeting was reported by John Most, secretary of the Branch. The meeting was held on April 21, at which a series of moving pictures was shown. These pictures were furnished through the courtesy of Alcoa, and disclosed the process of production and fabrication of aluminum. Prior to viewing the films, a short business meeting was held.

DREXEL BRANCH devoted its meeting on April 12 to a paper presented by W. P. Moore and M. A. Singer of the Savage Tool Company, Savage, Minn., on the subject of "Do-All" gages and gage instruments. The speakers gave a brief illustrated résumé of the development of precision measuring and demonstrated its indispensability to modern mass-production interchangeability of parts. Various applications of a precision measurement kit containing standard gage blocks, vernier gage blocks, center points, and the like, also were outlined.

The IOWA STATE BRANCH reports that Professor Nelson of the Aeronautical Engineering Department gave an illustrated lecture on "Postwar Air Transportation," at its April 12 meeting. At a short business meeting preceding the lecture, it was announced that Nick Pergakis had been selected as the student to receive the annual award for outstanding contribution to the Student Branch. This Branch met again on April 26, for a short business session, after which members enjoyed the Wright Aeronautical Corporation film, "Cyclone Combustion."

At an informal session on April 20, members of the KANSAS BRANCH met to discuss two student papers prepared for the Omaha Convention. Robert F. Maurer submitted, "Compressibility of Liquid Hydrocarbons as a Source of Error in Pipe Line Metering," and Joseph R. Wilson, "Cathodic Protection in Pipe Lines." This Branch met again on May 11 to congratulate two students, who had won second and third place in the student competition at the Omaha Convention, and to award the certificate of merit to Acting President Robert F. Maurer, a/s, for contributing most to the welfare of the organization during the 1943–1944 semester. Members then enjoyed two Allis-Chalmers films entitled, "The Magic of Steam," and "The Surface Condenser."

Private Plane "Ercoupe" Described at Maryland Meeting

The first meeting of the MARYLAND BRANCH was held on April 24, at which Fred E. Weick, chief engineer of the Engineering Research Corporation of Riverdale, discussed "Ercoupe," a private plane manufactured by the corporation. Mr. Weick discussed in detail the plane's safety features and its development. Prior to Mr. Weick's comments, a brief business meeting was held to elect Harry Loose treasurer of the Branch. The second meeting of this Branch on May 16 featured Prof. R. B. Allen of the civil-engineering department, who talked about his experiences while directing improvement work on the Boston & Maine Railroad a decade ago.

NEW MEXICO BRANCH met on May 2 to discuss plans for the Engineers' Circus to be held May 20, and to hear Mr. Hengesbach, sales engineer for a nationally known paint company, talk on the subject of "Paint—Its Composition for Various Uses." After refreshments were served, the meeting adjourned.

Under the supervision of Prof. A. C. Coonradt, chairman of the department of mechanical engineering, students of the NEW YORK UNIVERSITY BRANCH (Day), on May 3, conducted a tour of the campus power plant. The first smoker of the spring semester of this Branch was held on May 10 at which C. M. Larson, chief consulting engineer of the Sinclair Refining Company, New York, N. Y., spoke on the subject of "Lubrication." Mr. Larson's talk on lubrication, and particularly viscosimetry, was supplemented with charts and literature which he distributed. Two training films on modern ship-construction methods were viewed by members of this Branch at their noon meeting on May 24. The wide use of welding in construction and the extreme accuracy required in shipbuilding were particularly emphasized. At this meeting a committee was formed to promote the work of the Engineers' Council for Professional Development, and plans were announced for the contemplated A.S.M.E. boat ride. On May 30, the chairman reported that Morton Burde-Bell, secretary of this Branch, had joined the armed forces and that a successor would be appointed in the near future.

Evening Branch, N.Y.U., Learns of Helicopter Developments

NEW YORK UNIVERSITY EVENING BRANCH on February 11 met jointly with the student branch of the Institute of Aeronautical Sciences to hear W. A. Ayres of the Sperry Gyroscope Company give an interesting lecture on the "Helicopter—Past, Present, and Future." The lecture was illustrated with slides and motion pictures, the latter showing the U.S. Army Helicopters in the war zones, serving in the capacity of rescuer, observer, and fighter. At the joint meeting of this Branch and the A.S.C.E. Student Branch on April 26, Mr. Cleary of the *Engineering News Record* spoke on "Wartime Engineering in South America." Following Mr. Cleary's remarks, moving pictures were shown, depicting the improvements that have been made by United States engineers in Central and South America, as well as contemplated future plans.

The meeting of March 17 of OHIO STATE BRANCH was devoted to a paper on "The Engineer and the Postwar Era," presented by Professor Marco. A short discussion followed Professor Marco's talk. This Branch met on March 24 to hear Dr. Young give an interesting account of "Effects of High Altitude Flying." At the same meeting it was announced that Jay Antenen, the only contestant for the National A.S.M.E. speaking contest, would

A.S.M.E. STUDENT BRANCH AT NEW YORK UNIVERSITY, DAY BRANCH

represent the Branch at Detroit. Professor Marco again addressing the April 14 meeting of this Branch, read excerpts from an article, "Does An Engineer Need His Profession," written by W. E. Wickenden and published in the April, 1944, issue of MECHANICAL ENGINEERING.

Brooklyn-Queens Highway Discussed at Pratt Branch

PRATT BRANCH reported a meeting on May 9, at which Prof. A. W. Collard of the Pratt Institute faculty, and a structural engineer, discussed the proposed Brooklyn-Queens highway upon which he is working. Particularly interesting to the 85 members and guests present were Professor Collard's proposals of an elevated section directly above a subway and a sewage system, together with the problems involved with these factors. An open discussion followed.

R. Charlesworth, secretary of the PRINCETON BRANCH, reported that at the November 17 meeting a short talk was given by Leroy G. Phelps, who also showed the movie "Dark Rapture." This Branch met on December 17, to view two films, entitled, "Tank Destroyers" and "Current Newsreels," and to hear William G. Christy give a brief talk.

Dean Potter Briefs "Élite in Science," by Le Chatelier for Purdue Branch

Dean A. A. Potter was guest speaker on May 3 at the annual social meeting of PURDUE BRANCH, reviewing briefly a paper by Henry Le Chatelier entitled, "The Creation of an Intellectual Élite in Science and Industry." Quoting the famous French scientist, Dean Potter said, in part, "In order to be able to aspire to be a part of the intellectual élite, it is necessary to have four qualities, i.e., enthusiasm for work, imagination, judgment, and instruction." After Dean Potter's short addresss, entertainment was provided by Don Edwards, ventriloquist; Max Hoffman, who impersonated Holleywood stars; and Erwin Hahn, who gave a short juggling performance. Refreshments consisted of ice cream and cookies. Moving pictures entitled, "Steam Turbines," "Handle With Care," and "Design for Flying," featured the May 17 meeting of this Branch. The first film, produced by General Electric, presented a simplified description of the operating principles of steam turbines. The second film, produced at an explosives plant in Canada, showed the many precautions taken to protect personnel and property, while the third film, product of the Douglas Aircraft Corporation, outlined the many intricate details handled between the time an airplane is conceived on the drawing board and its first test flight.

The speaker on March 26 before the TENNESSEE BRANCH was Prof. Mack Tucker, who gave an interesting illustrated account of "Photography as a Hobby." Prior to Professor Tucker's comments, a short business session was held, at which the following officers for the summer quarter were elected: Jesse Brown, chairman; Arnold Krieger, vice-chairman, and Gene Holthofer, secretary-treasurer. Members of this Branch met again on May 10 to discuss plans for a hay ride, and to view two interesting sound films, "Excursions in Science Engineering," and "Sight Seeing at Home."

Members and guests of the UNIVERSITY OF CALIFORNIA BRANCH met on May 1, to see two Interesting motion pictures, "Fortress in the Sky," and "Swiss on White." A brief business meeting was held to appoint a committee for a dance contemplated by this Branch.

Plans for the A.S.C.E.-A.S.M.E. dance and an excursion to the Pasadena refrigerating plant were discussed at a joint meeting of the UNIVERSITY of SOUTHERN CALIFORNIA BRANCH and members of the A.S.C.E. on April 12. The meeting was concluded after members viewed a colored film describing the "P-38." At the April 26 meeting of this Branch, members heard Sharon Moody give the first of a contemplated series of student talks on boilers. Before the session closed, the secretary reported that approximately 20 members had gone on an inspection tour of the Pasadena refrigerating plant, which had proved extremely interesting and educational.

Virginia Polytechnic Branch Reports on Six Meetings

On April 10, the VIRGINIA POLYTECHNIC BRANCH met to enjoy a motion picture, "Santa Fe," which portrayed the difficult wartime transportation problems being encountered by the railroads, together with their practical solutions. This Branch met on April 17, to view the movie "Fairchild PT-19," and to elect G. A. Main circulation secretary in charge of publications. At the May 1 meeting, Prof. A. E. Bock presented a paper entitled, "Engineering Development of Aircraft Design," by Warren Furry, supervisor of Lockheed Engineering Training, which proved extremely interesting. After a brief discussion of the paper, members voted not to appoint a successor to Vice-Chairman T. E. Hall, who had joined the armed forces. The May 8 meeting featured Prof. W. J. Barber, honorary chairman, who discussed the basic courses in the mechanical-engineering curricula and the changes that have taken place during the last 10 years, after which the presiding officer, D. W. St. Clair, was awarded the booklet "An Autobiography of an Engineer," in recognition of his constructive activity in the Society's Student Branch. Members of this Branch met on May 15 to see two moving pictures. The first, "Design and Construction of Riley Steam-Generating Units," pointed out the importance of directional flow of fluid through boilers and water tubes, while the second, "Steam Turbines," illustrated the many advancements in steam power generation. A paper, "The History of Pipe," was presented at the May 29 session by Arthur F. Roberts, Jr., chief engineer of the Lynchburg Foundry Company, Radford, Va., which was then thoroughly discussed by Frank Carring-

ton, Jr., chief metallurgist of the Lynchburg Company.

Students Cover Many Subjects at Yale

Student papers presented at six meetings of YALE BRANCH were reported by the secretary of the Branch as follows: April 25—"Preparing for War," by F. M. Hicks; "Parachutes," by H. E. Zimmerman; "Landing Gear," by L. A. Rossi; "The Great Lakes Ore Trade," by A. S. Linzel. May 2—"This Game of War," by J. F. Hughes; "Our Lighter-Than-Air-Craft," by W. O. R. Korder; "Canada," by Mr. Shattuck. May 9—"Synthetic Diamonds," by R. P. Tucker; "Airports at Sea," by W. A. P. Meyer; "The Evolution of the Hellcat," by A. R. Jones; "Photoelectric Cell," by Mr. Stringwall. May 16—"The A.S.M.E. Sectional Meeting at Tufts College," by R. P. Tucker; "The Pressure Cooking of Potatoes," by B. B. Blickman; "Freak Ships," by L. P. Mitchell; "The Thunderbolt," by J. A. Kloss; "Our State Department," by A. Allport. May 23—"Plastic Navigation," by S. C. Cameron; "Fox Hunting—Especially in Ohio," by R. E. Davis; "Explosives," by W. E. Woollenweber; "Eat, Drink, and Be Wary," by R. M. Thompson. May 30—"Putting a Scale on Literature," by A. H. Swett; "Seeing the World's Fair," by D. Nardelli, and "A Life Long Experiment," by R. G. Wynne.

Engineering Societies Personnel Service, Inc.

These items are from information furnished by the Engineering Societies Personnel Service, Inc., which is under the joint management of the national societies of Civil, Electrical, Mechanical, and Mining and Metallurgical Engineers. This Service is available to members and is operated on a co-operative, nonprofit basis. In applying for positions advertised by the Service, the applicant agrees, if actually placed in a position through the Service as a result of an advertisement, to pay a placement fee in accordance with the rates as listed by the Service. These rates have been established in order to maintain an efficient nonprofit personnel service and are available upon request. This also applies to registrants whose notices are placed in these columns. All replies should be addressed to the key numbers indicated and mailed to the New York office. When making application for a position include six cents in stamps for forwarding application to the employer and for returning when necessary. A weekly bulletin of engineering positions open is available to members of the co-operating societies at a subscription of $3 per quarter or $10 per annum, payable in advance.

New York	Boston, Mass.	Chicago	Detroit	San Francisco
8 West 40th St.	4 Park St.	211 West Wacker Drive	100 Farnsworth Ave.	57 Post Street

MEN AVAILABLE[1]

GRADUATE ENGINEER, 39, now employed and with 20 years' experience in sales and manufacturing. Desires position as sales engineer with progressive company. Middle West preferred, particularly Indiana. Me-847.

GRADUATE MECHANICAL ENGINEER, 30 years' experience in all phases of power and industrial plant design, operation, and maintenance. Desires permanent connection as chief engineer, plant engineer, or development engineer. Southwest preferred. Me-848-1755-Chicago.

CHIEF PLANT ENGINEER, M.E., with diversified experience in all phases of plant engineering, including plant layout, design, construction, maintenance of industrial equipment and buildings, operation of boilerhouses, chemical by-product plant, refrigeration, machinery and shop supervision. Age 46. Me-849-1649-Chicago.

POSITIONS AVAILABLE

CHIEF ENGINEER to be in charge of design as well as supervision of all plant maintenance, of building, mechanical, and electrical equipment. Ohio. W-2792-D.

MECHANICAL ENGINEER. Should be thoroughly acquainted with mechanical apparatus involved in chemical-plant construction and maintenance. Prefer man with considerable experience in installation of piping pumps, machinery, and other chemical-plant apparatus. Will be required to co-ordinate with civil and electrical engineers in layout of plant apparatus and equipment. Definitely postwar position offering splendid opportunity to right man. $5000. Northern New York State. W-3819.

PRODUCTION ENGINEER. Must have production-line experience. Mostly metal-turning operations. Should be executive type able to handle all types of personnel, be thoroughly acquainted modern production methods. Permanent. $7500–$8000. Delaware. W-3821.

DIESEL ENGINE DESIGNER with at least 5 or 10 years' experience in this field for layout and detail work. Salary open. New York, N. Y. W-3831.

ENGINEER, top grade, with experience on small, high-speed, Diesel-engine design, capable of taking charge of group of draftsmen and designers in carrying complete design through development stage up to production. Permanent with future to right man. New York metropolitan area. W-3833.

CHIEF ENGINEER for research and development department. Projects are variegated, including Diesel-engine investigation, development of lawn mowers, development of new type of air compressor and rotary-vane pumps, designing of automatic screw machines, electric generators, and induction heating units. Prefer man with excellent theoretical background and as diversified experience as possible. $8000–$12,000. New York, N. Y. W-3842.

SOLICITOR OF PATENTS with imagination and scientific background, interested in prosecution of patent applications and underlying research work requiring use of ordinary knowledge and ability. Position open with patent-law firm representing as patent counsel large number of leading corporations. Substantial pay with reasonable advancement. Salary open. Ohio. W-3845-D-1859.

DESIGNING ENGINEER, mechanical, with some experience in oil-pollution separation system. Some knowledge of concrete and reinforcing rods. Salary open. New York, N. Y. W-3847.

MECHANICAL ENGINEER with considerable production machine-shop experience. Also would like some tool and die experience. Want engineer familiar with various machining and tooling operations which cover manufacture of small parts. Would investigate and work out many varied production difficulties which occur. Operations include die casting, die-cast machining, bakelite molding, bakelite processing, and usual run of machine-shop operations. Connecticut. W-3850.

CHIEF MANUFACTURING EXECUTIVE, 35–45, with well-rounded manufacturing experience, both in metalworking and in process type of production. Should be graduate engineer, preferably in chemical engineering. Should have outstanding ability and skill in human relations and in dealing with individuals and groups on all occupational levels. Should have experience in supervision of metalworking establishment, preferably one producing mechanical equipment under job-lot conditions. Experience also should include process type of manufacture such as would be gained in manufacture of chemicals. $9000–$10,000 year. W-3855.

MACHINE DESIGN AND DEVELOPMENT ENGINEER who can supervise group of designers on building of textile machines. Must have some previous experience in design of some textile machinery. Salary open. Ohio. W-3865.

PRODUCTION ENGINEER to direct and co-ordinate production of light sheet-metal stamping plant. Must know die design and tooling. Will also head metals department. Permanent. $6000–$7000. Connecticut. W-3866.

MECHANICAL DESIGN ENGINEER, graduate mechanical, with at least 10 years' total experience as engineering designers of motor-driven appliances. Minimum of 5 years' experience essential in designing, for quantity production, of self-contained air-conditioning units equipped with refrigerating machines. Must have thorough working knowledge of refrigeration engineering and psychrometry. State minimum salary expected and draft classification. Pennsylvania. W-3875.

DESIGN ENGINEER experienced in development of semitrailers, particularly informed regarding utilization of the newer, lightweight metals; acquaintance with current prototype chassis construction also essential. Postwar position. Maryland. W-3882.

TIME AND MOTION STUDY ENGINEERS for setting standards and writing of operation sheets for machine shop. Salary open. Northern New Jersey. W-3898.

ENGINEERS. (a) Production manager, mechanical engineer, familiar with all phases of machine-parts production. Should have some years' experience as assistant production manager in related work. Will assume full re-

[1] All men listed hold some form of A.S.M.E. membership.

sponsibility for seeing that work schedules are met. Present force about 200 production people with potentially several times that number to be employed. (*b*) Personnel manager, graduate, thoroughly familiar with present labor legislation. Should have knowledge of machine-shop work so that personnel department can select proper men for shop. Should have practical experience in personnel work. Will organize and direct activities of department. (*c*) Training instructor, preferably graduate, able to work between the government training agencies and company and organize suitable lesson material for the employees. Will conduct in-plant courses where qualifications permit, and outline material to be given employees by outside agencies. Salaries open. New Jersey. W-3901.

TECHNICAL REPRESENTATIVE for promoting use of seized patents by such means as holding conferences with manufacturers, giving talks before trade and professional groups, promoting exhibits of patents and co-operating with planning agencies and other organizations and preparation of publicity material. Must have diversified technical training in new-products development, as well as merchandising experience. $5400–$6200 year. Will work in New York City area and New York State. W-3919.

INDUSTRIAL ENGINEER with at least ten years' experience, preferably in chemical industry, for chemical plant in upstate New York. $6000 year. W-3921.

MECHANICAL ENGINEER, specialist in plant efficiency and wage incentive. Must have experience in metalworking field; stamping, machine shop, forging and welding, etc. Must have thorough knowledge of theory and operations of wage-incentive plan. Should be able to exercise good judgment in approving time standards and be able to supervise time study and rate-setting department. Permanent. $4200–$5400. Pennsylvania. W-3928.

RESEARCH AND DEVELOPMENT MANAGER for postwar work on electronic and scientific precision instruments. Salary open. New York, N. Y. W-3930.

ENGINEERS. (*a*) Process engineers with background of tooling and manufacturing methods. Should be familiar with gaging and tolerances from practical manufacturing standpoint. Requires co-ordination between engineering manufacturing and assembly. (*b*) Engineer who has made a specialty of metallurgical problems, or chemical engineer. Must be experienced in plating procedure and have knowledge of metallurgical analysis. Desirable, electronic experience. Must be graduate, preferably chemical. Connecticut. W-3942.

Candidates for Membership and Transfer in the A.S.M.E.

THE application of each of the candidates listed below is to be voted on after July 25, 1944, provided no objection thereto is made before that date, and provided satisfactory replies have been received from the required number of references. Any member who has either comments or objections should write to the secretary of The American Society of Mechanical Engineers immediately.

KEY TO ABBREVIATIONS

Re = Re-election; Rt = Reinstatement; Rt & T = Reinstatement and Transfer to Member.

NEW APPLICATIONS

For Member, Associate, or Junior

APELGRAIN, MERL D., Guayaquil, Ecuador, S. A.
BARTEN, J. H., Baltimore, Md.
BARTHOLOMAEI, H. A., Baltimore, Md. (Rt)
BASTIAN, EARL L., Scarsdale, N. Y. (Rt & T)
BONSTOW, THOS. L., Westminster, England (Rt)
BYRNE, HARRY E., Downers Grove, Ill.
CARMAN, THORNTON S., Cleveland, Ohio
CORNELL, SIDNEY, West Hartford, Conn.
DAVIS, FLOYD E., Gary, Ind.
DE GARMO, E. PAUL, Berkeley, Calif.
DISHNER, J. W., Oak Ridge, Tenn.
DRUHAN, JOHN L., Libertyville, Ill.
FRENTZEL, G. MARTIN, St. Louis, Mo.
GALLAGHER, PAUL, Kingsport, Tenn. (Rt)
GAY, CHAS. L., Birmingham, Ala.
GEIGER, GUSTAV R., Philadelphia, Pa.
HINDMAN, W. P., Milton, Pa.
HOLLIS, OLIVER N., Boston, Mass. (Rt & T)
INGERSOLL, R. J., Nashville, Tenn.
ISRAELSON, ARLO F., South Pasadena, Calif.
KEEL, K. O., Cleveland, Ohio
KEHOE, A. H., New York, N. Y.
KNIGHT, JOHN M., New York, N. Y.
KRAUS, B. F., Hyde Park, Mass.
LEEBOV, NATHAN, Pittsburgh, Pa.
LEONARD, LEONID V., Los Angeles, Calif. (Rt & T)
LITTLE, DAVIS H., Dorchester, Mass.
LOWREY, JOHN C., Swansea, Ontario, Canada.
MCARTHUR, WARREN, Bantam, Conn.
MCGEE, PATRICK A., New York, N. Y.
MEINERS, RICHARD H., Wauwatosa, Wis.
MERSHON, CLARENCE E., Portland, Oregon
MITCHELL, ORVILLE, Dallas, Texas
MOLITOR, ARVID A., Elgin, Ill.
NATKINS, EPHRAIM N., New York, N. Y.
NEVELL, THOS. G. W., Riverside, Conn.
NEWELL, WM. S., Bath, Maine
NEWTON, R. C., Wellesley Hills, Mass. (Rt)
O'BRIEN, J. E., Oakland, Calif.
PETERS, FRED P., Chatham, N. J.
POLANER, JEROME L., Newark, N. J.
SASSEN, GEORGE, Jamaica, N. Y.
SIGMUND, HERBERT A., Camden, N. J.
SMITH, OLIVER H., New York, N. Y.
SPRAY, ELLIS L., Pittsburgh, Pa.
STAMPFLE, ROBT. B., Bethlehem, Pa.
STEPHENSON, DALE Q., Upper Darby, Pa.
THOLL, JOHN E., Needham Heights, Mass.
THOMPSON, WM. D., St. Louis, Mo. (Rt)
TIEDEBERG, JOHN W., JR., Teaneck, N. J.
TIERMAN, JAS. B., Long Beach, Calif.
TRAILL, JOHN W., Victoria, Australia
VAN WINKLE, E. M., New York, N. Y.
WALTON, E. GORDON, JR., Dallas, Texas
WANG, S. C., New York, N. Y.
WERNER, HERBERT B., Aberdeen, Md.
WESTAWAY, CLARENCE R., Boston, Mass.
WODTKE, FRANK R., Harrison, N. J. (Rt)
WOOD, O. WENDELL, Rahway, N. J. (Rt)
ZAPATA, JUAN V., Milwaukee, Wis.

CHANGE OF GRADING

Transfers to Fellow

BOSTON, ORLAN W., Ann Arbor, Mich.
CADWALLADER, H., JR., Philadelphia, Pa.

Transfers to Member

DOHRENWEND, CLAYTON O., Chicago, Ill.
HAHN, RAYMOND P., Parkville, Mo.
INGRAM, WM. T., Detroit, Mich.
LAUGHLIN, G. C., Chicago, Ill.
ROBINSON, CHAS. S. L., West Newton, Mass.
WATSON, RALPH M., Bloomfield, N. J.

Necrology

THE deaths of the following members have recently been reported to headquarters:

CHALMERS, JOHN B., May 23, 1944
ERRINGTON, FRANKLIN A., March 18, 1944
HART, HOWARD S., March, 1944
KLOSSON, MICHAEL M., April 11, 1944
LEWIS, BRAYTON S., May 24, 1944
LINCOLN, CHARLES S., May, 1944
MCCONNELL, ROBERT S., February 9, 1944
MONTGOMERY, GRAHAM L., March 4, 1944
PENRUDDOCKE, J. H., April 12, 1944
RICHARDSON, MAURICE F., April 21, 1944
SLUSS, ALFRED H., April 17, 1944
STARK, Willet E., May 10, 1944
STEWART, FREDERICK C., May 4, 1944
SWAUGER, JOHN S., May 25, 1944
WORDEN, EUCLID P., May 27, 1944

A.S.M.E. Transactions for June, 1944

THE June, 1944, issue of the Transactions of the A.S.M.E., which is the *Journal of Applied Mechanics*, contains:

TECHNICAL PAPERS

Measurement of Dynamic Stress and Strain in Tensile Test Specimens, by R. O. Fehr, E. R. Parker, and D. J. DeMicheal
Heat Effects in Lubricating Films, by A. C. Hagg
Shrink-Fit Stresses and Deformations, by A. W. Rankin
Measurement of the Damping of Engineering Materials During Flexural Vibration at Elevated Temperatures, by Carl Schabtach and R. O. Fehr
Nozzles for Supersonic Flow Without Shock Fronts, by A. H. Shapiro
Forced and Free Motion of a Mass on an Air Spring, by B. Sussholz
Second Law of Thermodynamics for Changes of State and Quantity of Working Substance With Particular Reference to Steam Engines, by G. Zerkowitz
An Investigation of the Cross-Spring Pivot, by W. E. Young

DISCUSSION

On previously published papers by M. Hetényi; M. Muskat and F. Morgan; and D. C. Drucker

BOOK REVIEWS